Pre-implementation briefing: RUC upgrade – 2008 Planned for Wed 12 Nov 08

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Major transitions:

- RUC13 change package – radar reflectivity assimilation, TAMDAR, mesonet, model physics – radiation, convection, LSM

4 Nov 2008

NCEP

Earth System Research Laboratory
SCIENCE, SERVICE & STEWARDSHIP

Changes for oper RUC upgrade

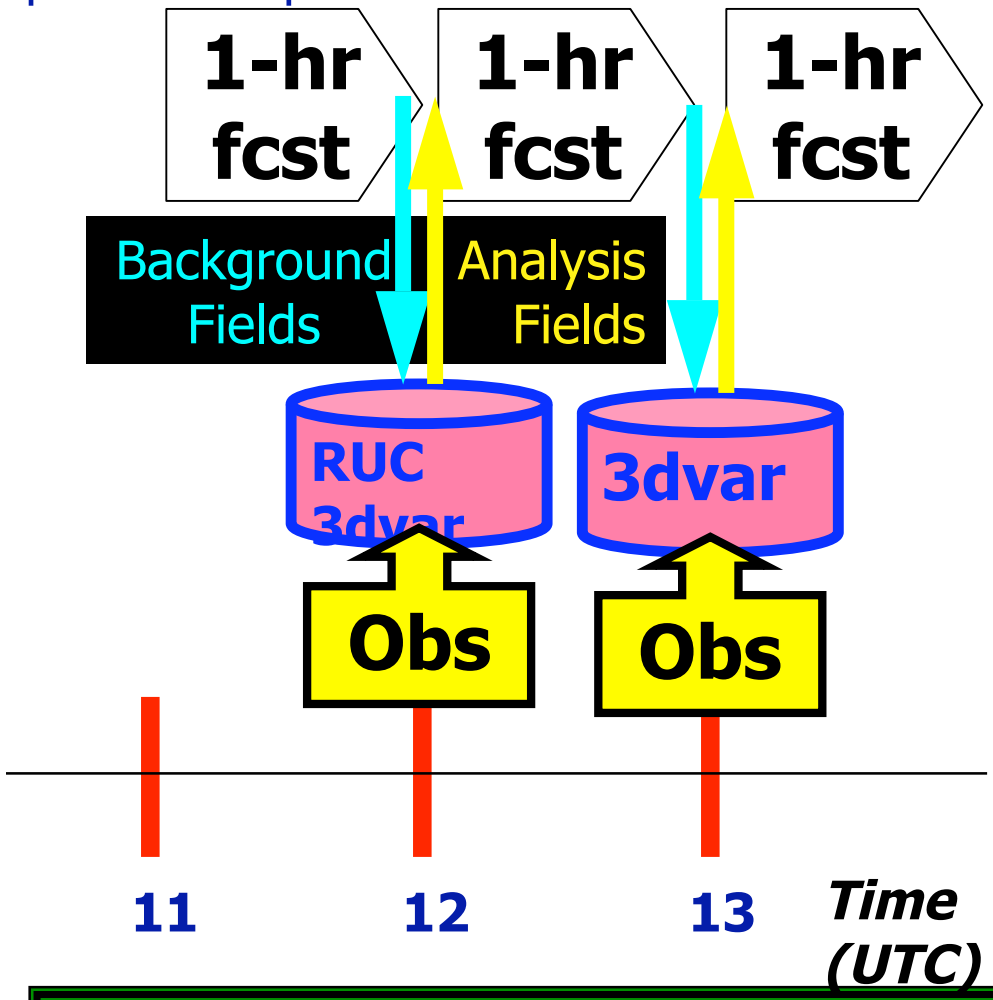
- Assimilation
  - Use of **radar reflectivity** in diabatic DFI in RUC model (also, hydrometeor assimilation component)
  - **Mesonet winds** using mesonet station uselist
  - **TAMDAR aircraft** observations
    (TAMDAR impact parallel RUC tests at GSD)

- Model physics
  - RRTM longwave radiation - eliminates sfc warm bias
  - Mod to Grell-Devenyi – decrease areal coverage
  - Mods to RUC land-sfc model
    - fresh snow density - nighttime temps over snow cover
    - limit on melting rate- allows warmer 2m temps
- Post-processing
  - add reflectivity fields, a few others, improved RTMA downscaling

RUC parallel web site:
http://www.emc.ncep.noaa.gov/mmb/ruc2/para

New observations assimilated -- RUC upgrade

Cycle hydrometeor, soil temp/moisture/snow plus atmosphere state variables



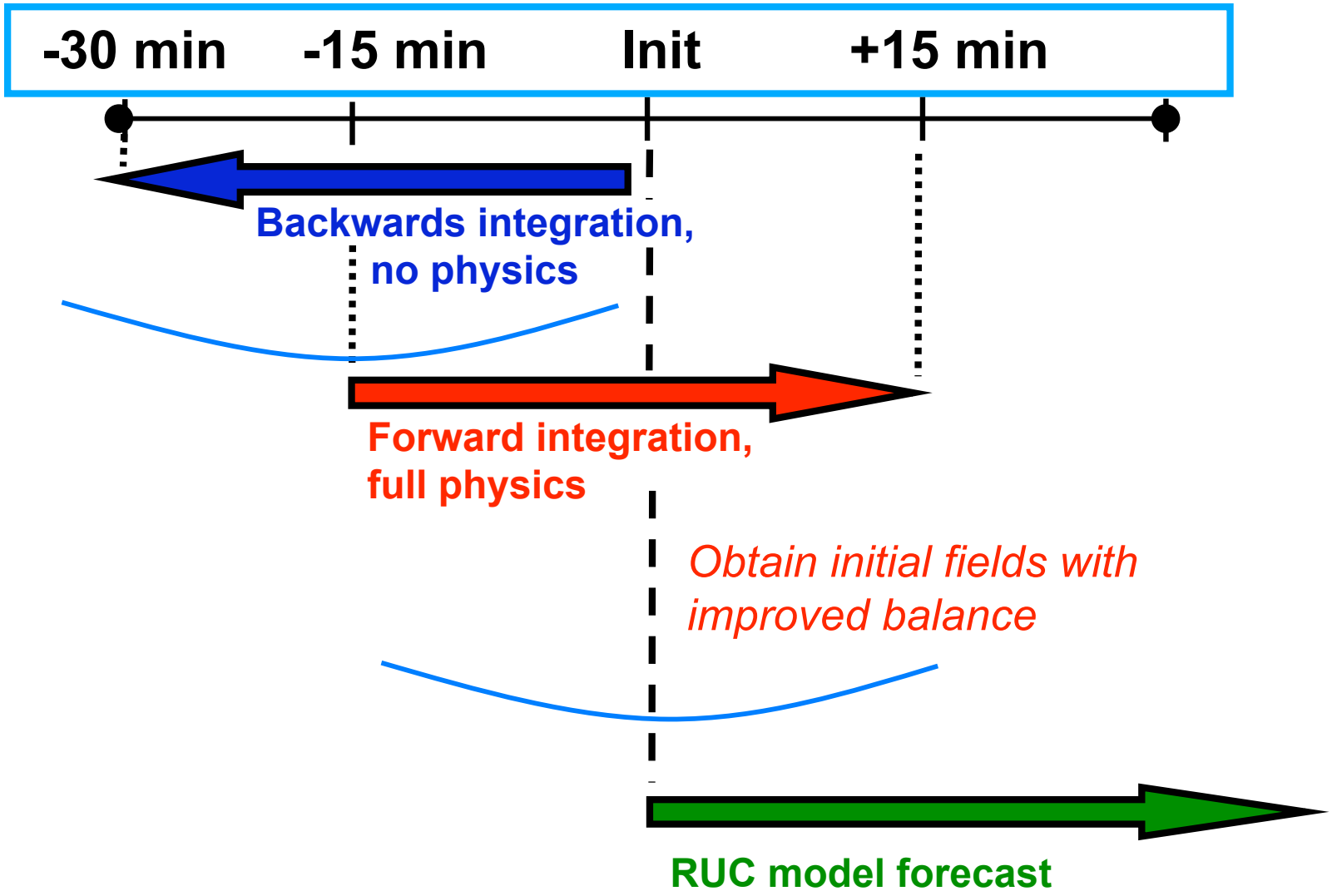
Hourly obs in 2008 RUC

Data Type	~Number
Rawinsonde (12h)	80
NOAA profilers	30
VAD winds	110-130
PBL – prof/RASS	~25
Aircraft (V,temp)	1400-7000
→ **TAMDAR (V,T,RH)**	0 - 800
Surface/METAR	1800-2000
Buoy/ship	100- 200
GOES cloud winds	1000-2500
GOES cloud-top pres	10 km res
GPS precip water	~300
Mesonet (temp, dpt)	~7000
→ **Mesonet (wind)**	2000-4000
METAR-cloud-vis-wx	~1600
→ **Radar reflectivity**	2km

RUC Hourly Assimilation Cycle

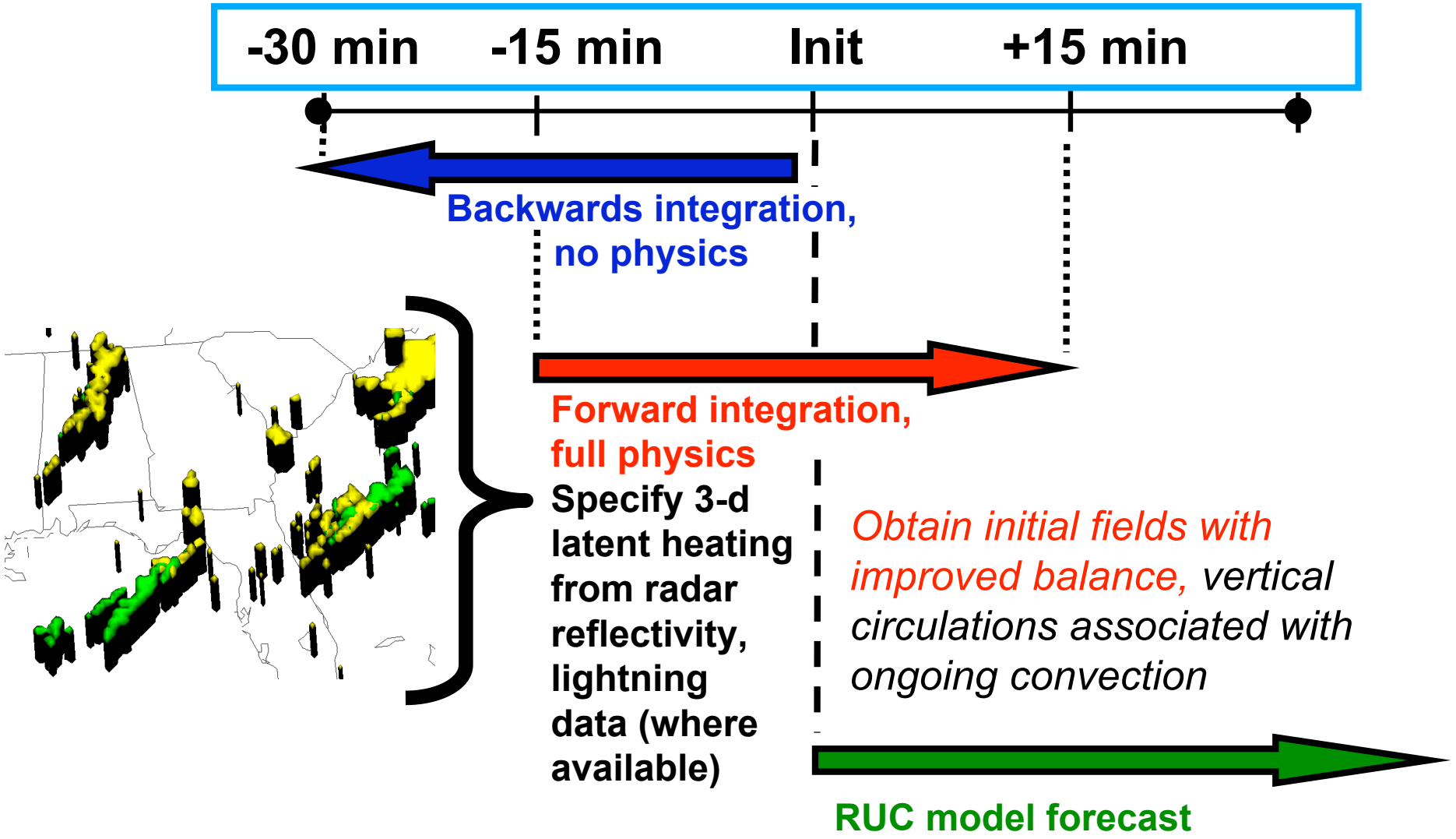
RUC Diabatic Digital Filter Initialization (DDFI)

Initial DFI in RUC model at NCEP - 1998 - adiabatic DFI
Diabatic DFI introduced at NCEP - 2006

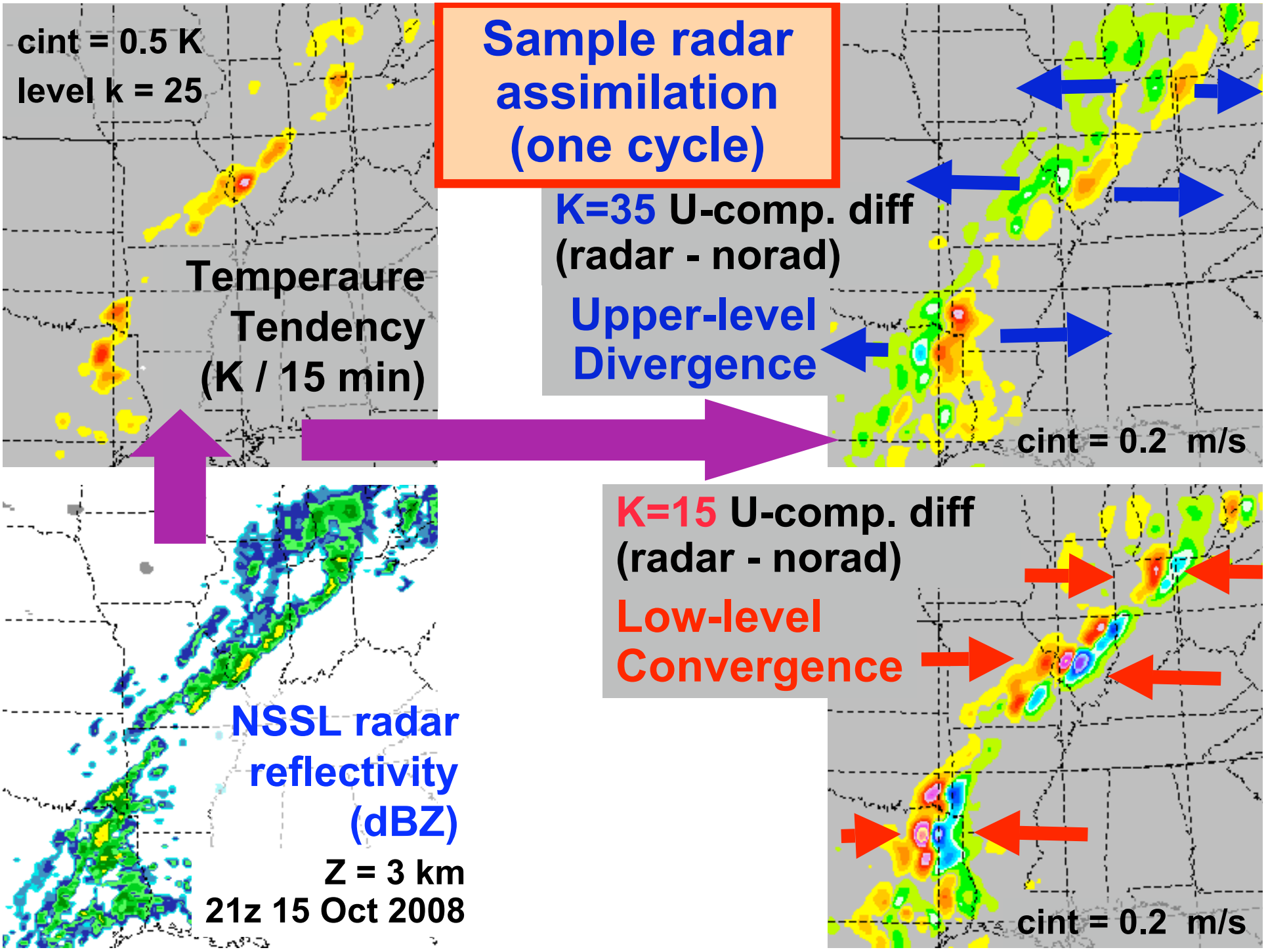


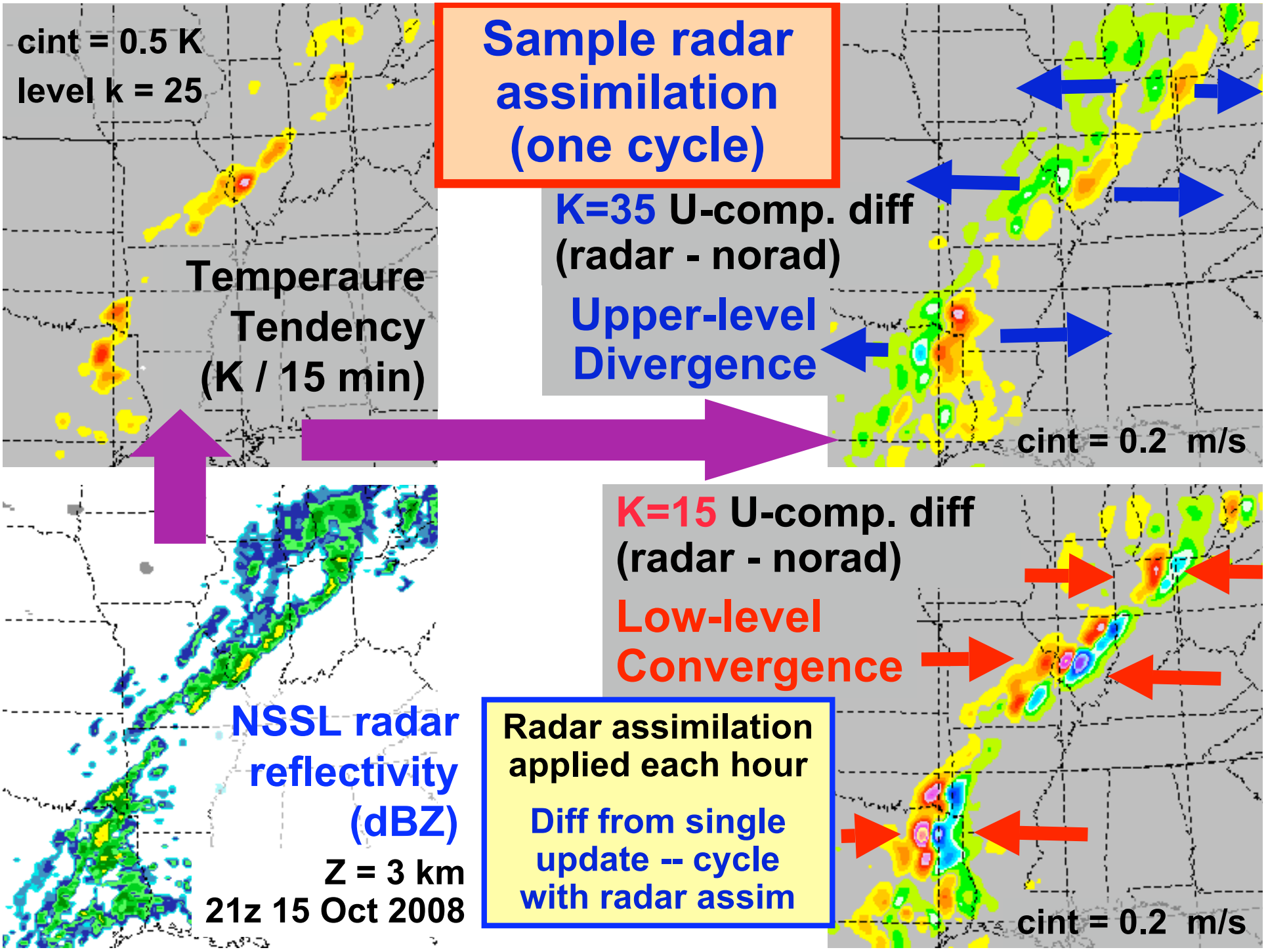
Diabatic Digital Filter Initialization (DDFI)

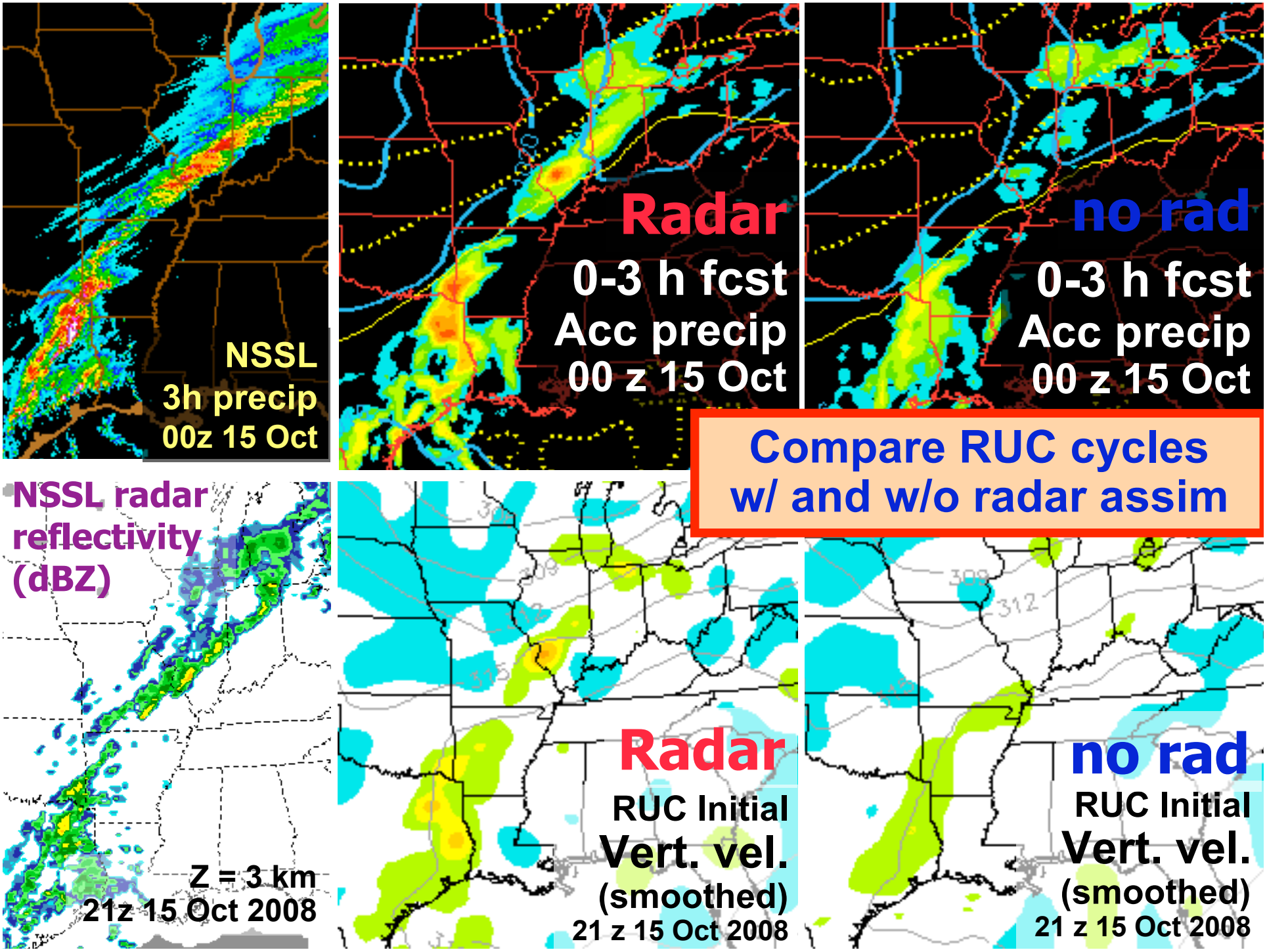
New - add assimilation of radar data



Radar reflectivity assimilation in RUC


cint = 0.5 K
level k = 25
Temperaure Tendency (K / 15 min)
Sample radar assimilation (one cycle)
K=35 U-comp. diff (radar - norad)
Upper-level Divergence
cint = 0.2 m/s
NSSL radar reflectivity (dBZ)
Z = 3 km
21z 15 Oct 2008
K=15 U-comp. diff (radar - norad)
Low-level Convergence
cint = 0.2 m/s


cint = 0.5 K
level k = 25
Temperaure Tendency (K / 15 min)
Sample radar assimilation (one cycle)
K=35 U-comp. diff (radar - norad)
Upper-level Divergence
cint = 0.2 m/s
NSSL radar reflectivity (dBZ)
Z = 3 km
21z 15 Oct 2008
Radar assimilation applied each hour
Diff from single update -- cycle with radar assim
K=15 U-comp. diff (radar - norad)
Low-level Convergence
cint = 0.2 m/s

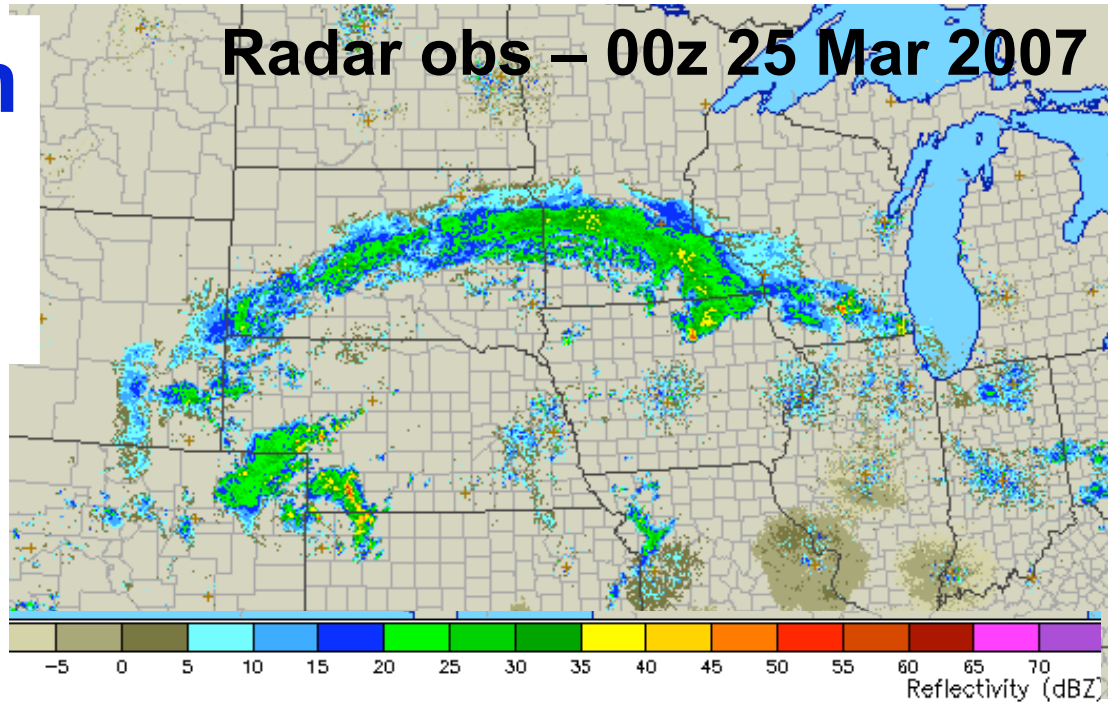

NSSL
3h precip
00z 15 Oct
Radar
0-3 h fcst
Acc precip
00 z 15 Oct
no rad
0-3 h fcst
Acc precip
00 z 15 Oct
Compare RUC cycles
w/ and w/o radar assim
NSSL radar
reflectivity
(dBZ)
Z = 3 km
21z 15 Oct 2008
Radar
RUC Initial
Vert. vel.
(smoothed)
21 z 15 Oct 2008
no rad
RUC Initial
Vert. vel.
(smoothed)
21 z 15 Oct 2008

Advantages of radar assimilation procedure

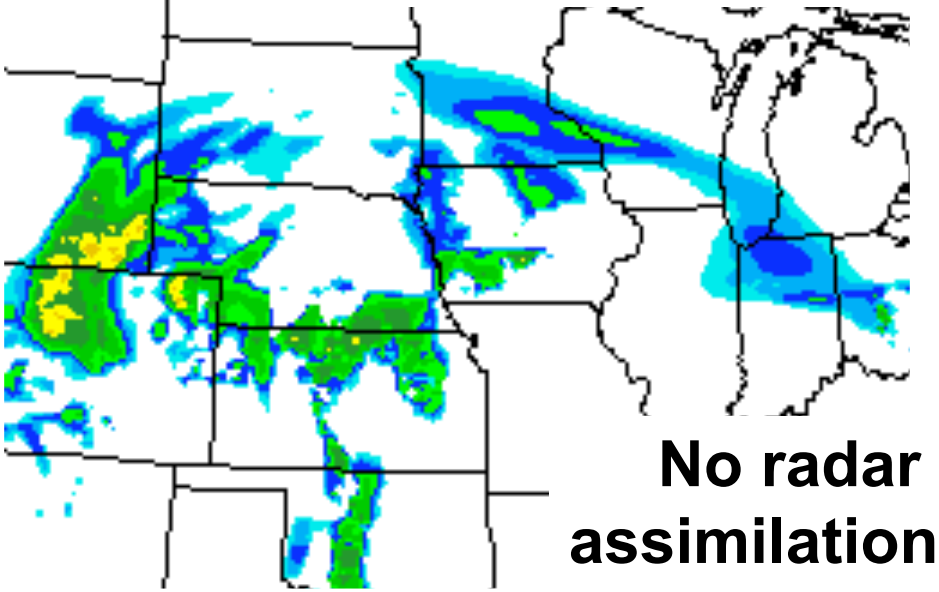
1. **Minimal shock to model**
   - Coherent wind, temperature, moisture fields evolve in response to heating within DDFI
2. **Very little additional computer cost**
   - DDFI already used to control noise
3. **Independent of model or physics schemes**
   - Applied to RUC and Rapid Refresh WRF

Radar assimilation in RUC - winter storm example

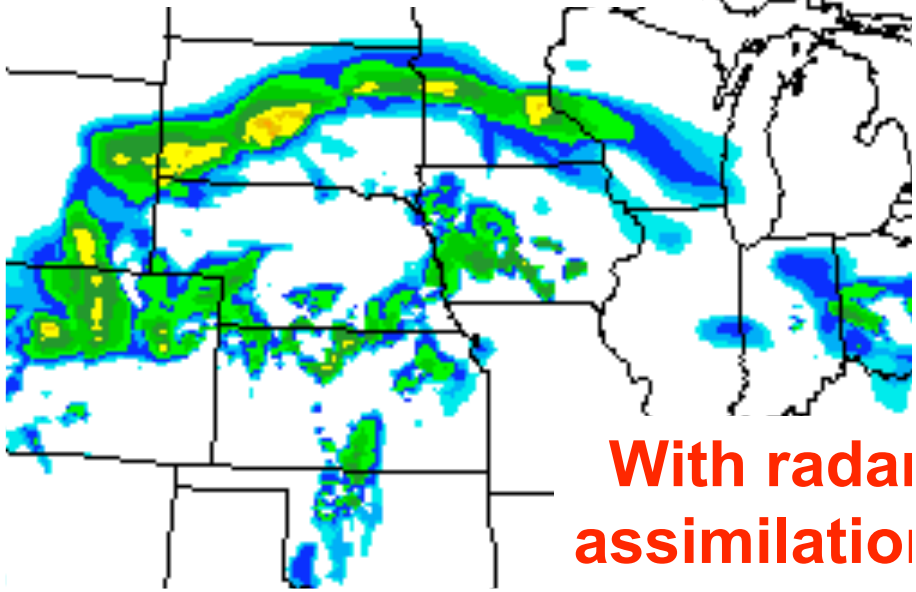
Also, added simulated radar reflectivity field to RUC output



RUC 3-h forecasts valid 00z 25 Mar 2007



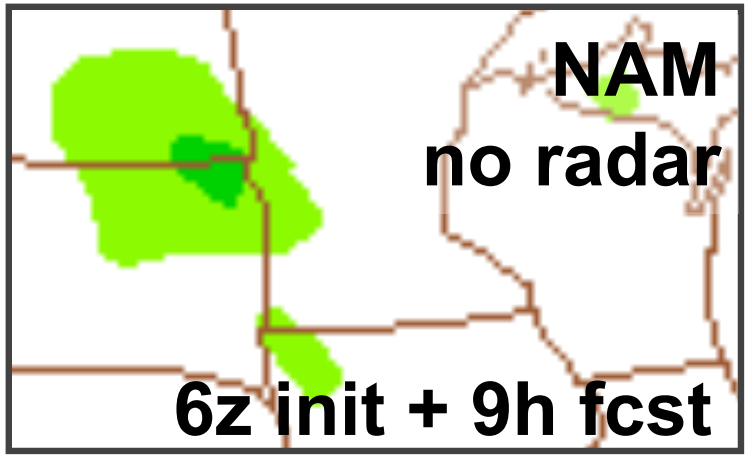
No radar assimilation

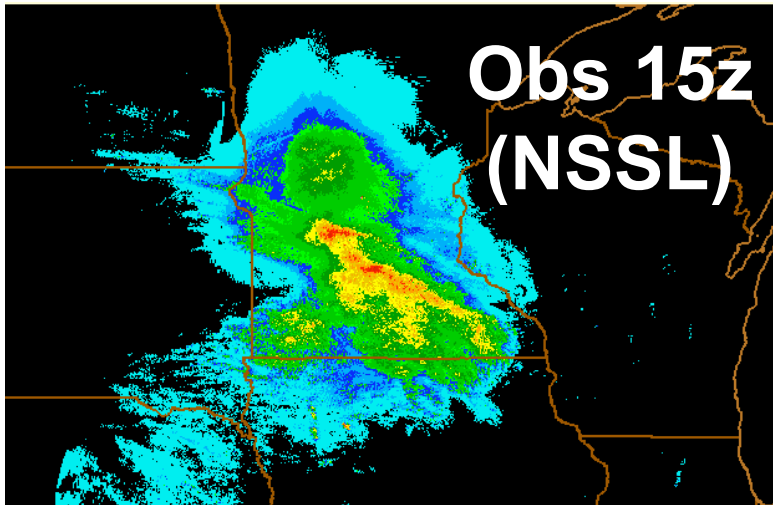


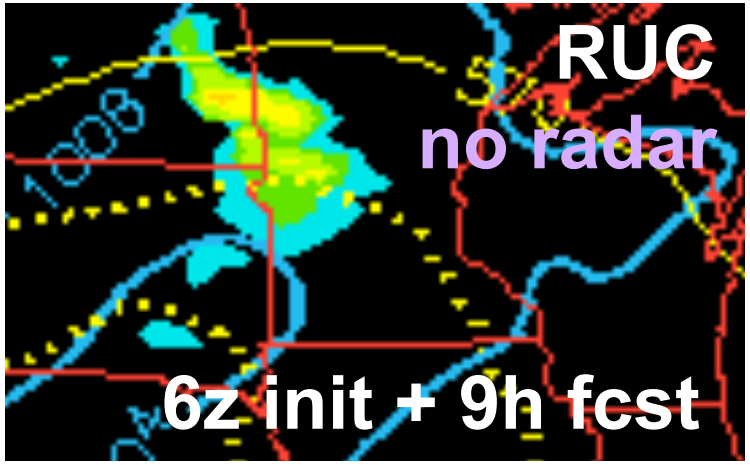
With radar assimilation

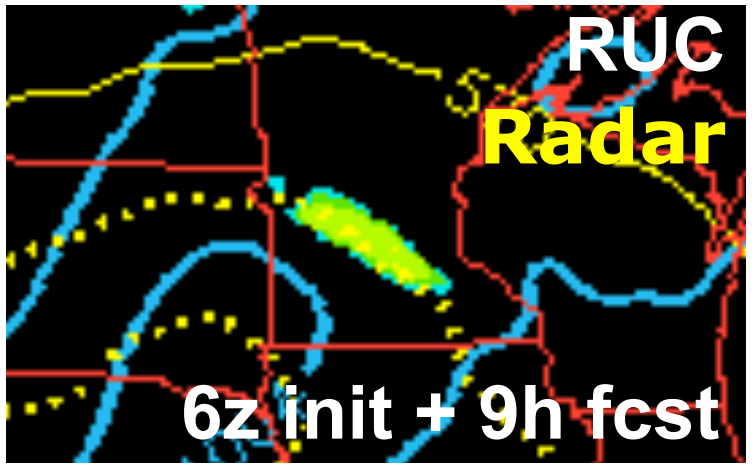
3-h accum. precip.

Valid 15z 31 July 2008





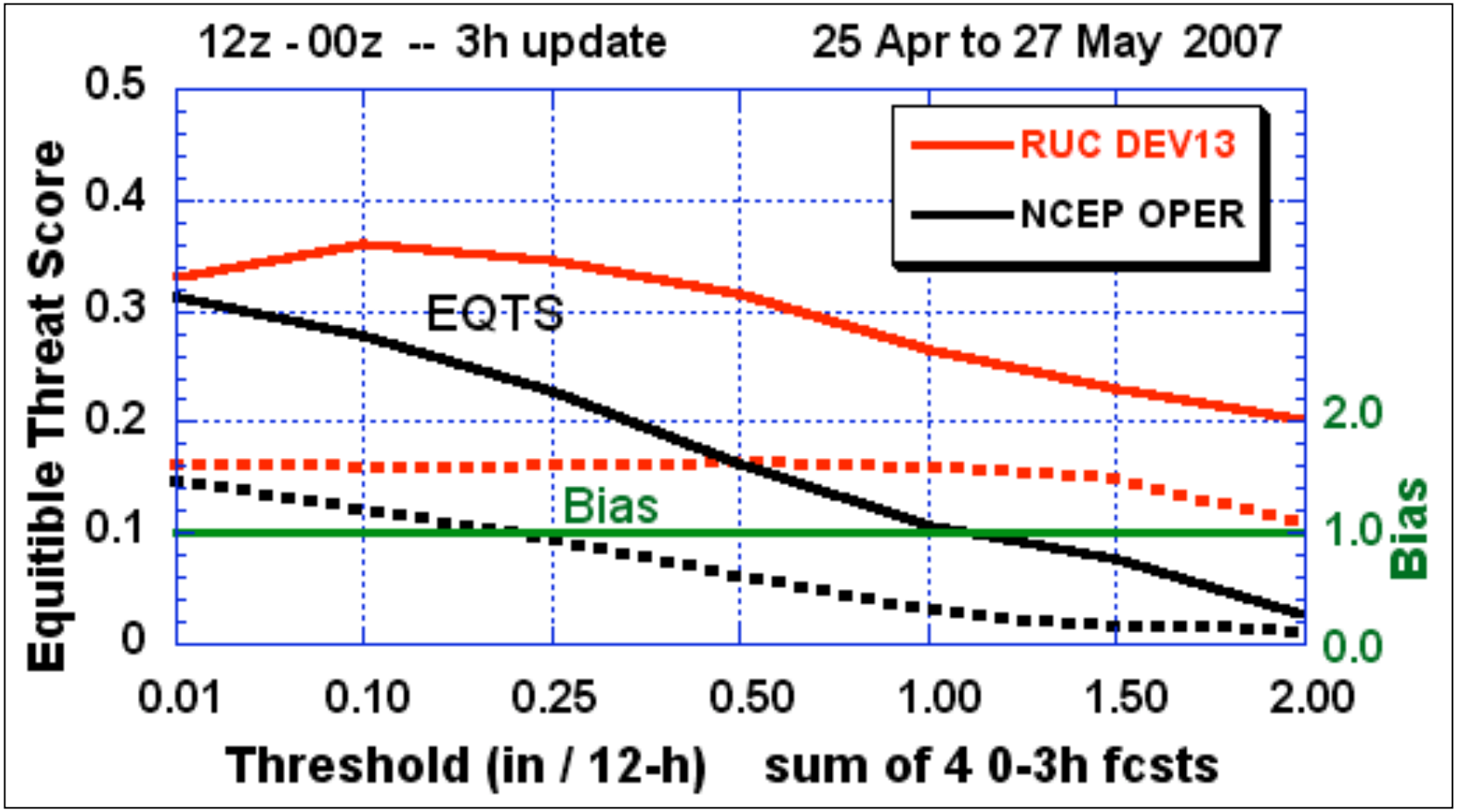




RUC radar assimilation improves forecasts out to 9-h lead-time

Radar assimilation impact on 3-h precipitation skill scores

- Significant improvement in ETS and bias
- Spring - daytime



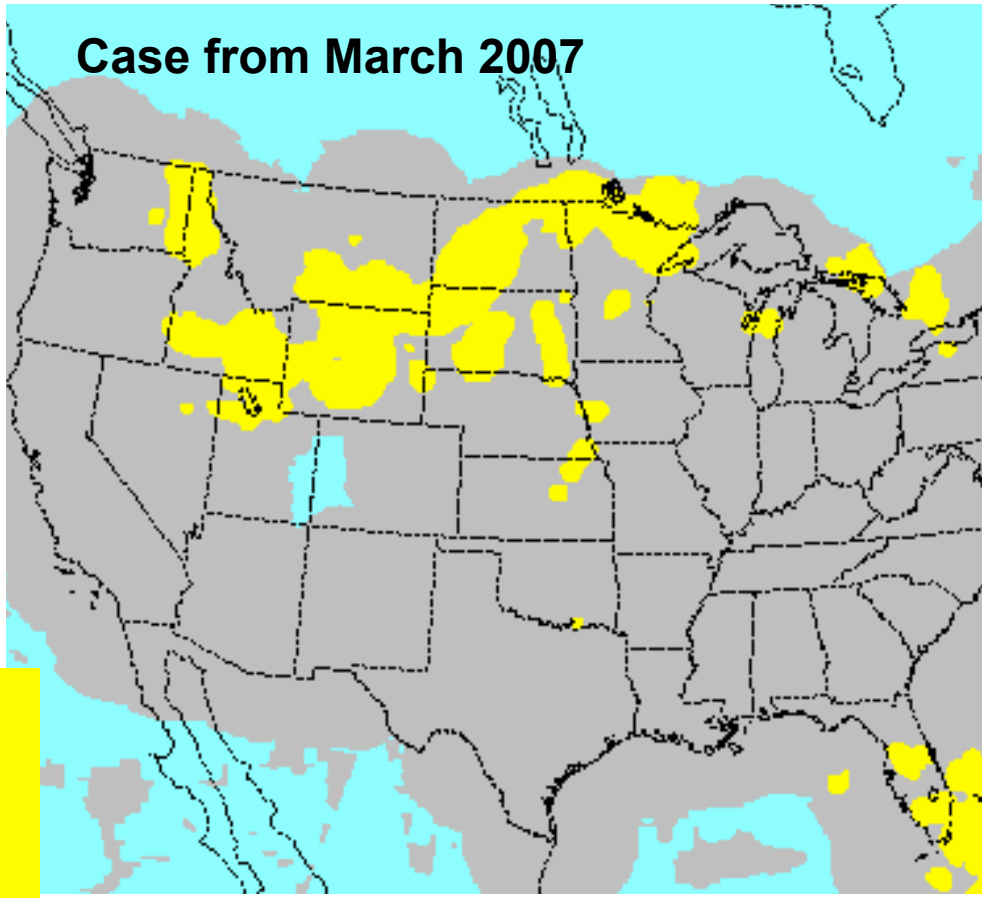
Radar reflectivity assimilation

Part 2 – convection suppression (for cap in Grell-Devenyi scheme)

- Define suppression areas as follows:

- No reflectivity > 20 dbZ within 100 km
- Depth of radar coverage > 300 hPa
- Augmented by GOES fully clear areas

Design in RUC model:
Specify min cap depth as 0 hPa to limit convection in DFI *and* first 30 min in actual forecast

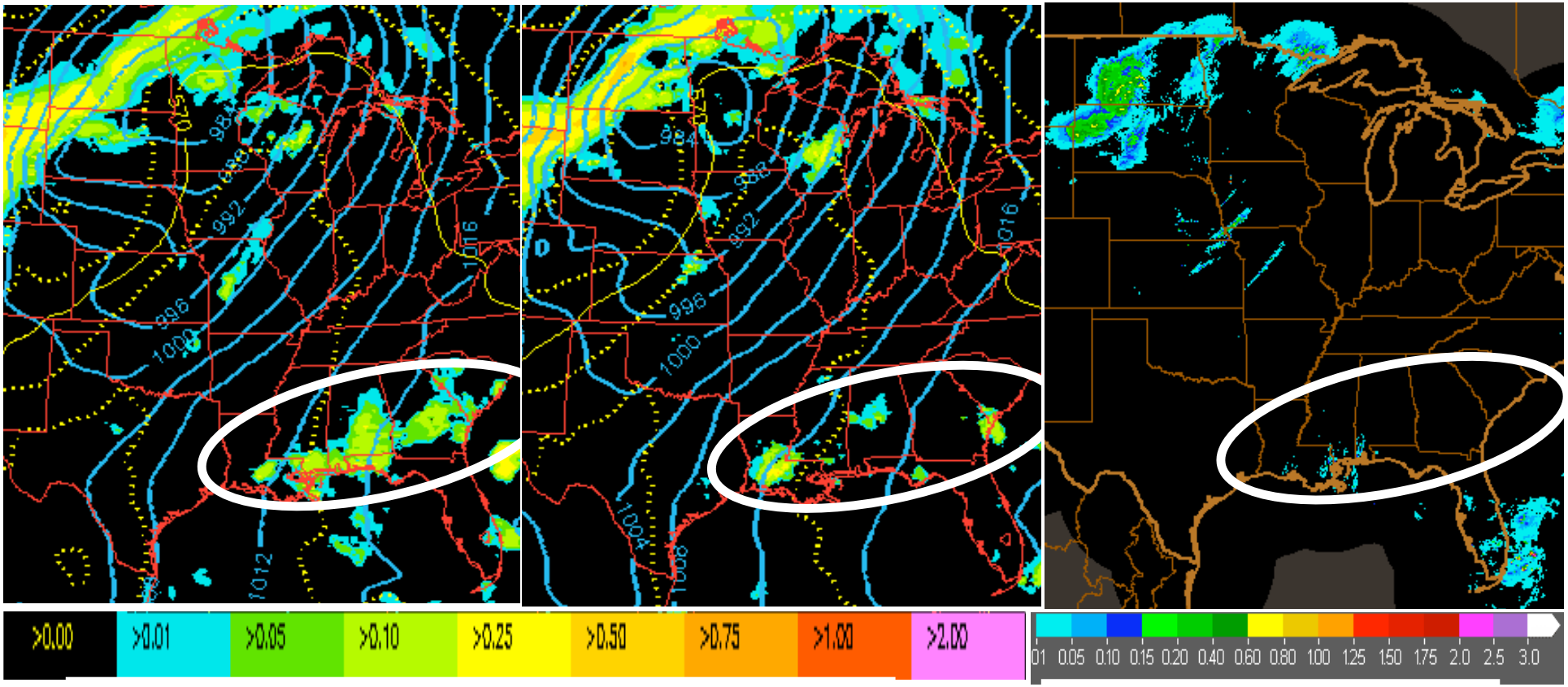


Convective suppression example

Control - radar assim without suppression

Add conv suppression to radar assimilation

NSSL 3-h precipitation



Real-time 3-h forecasts valid 15z 7 June 2007

Valid 15z 7 June 2007

convective suppression - *How does it work? –*

Reduces latent heating, vert. motion in erroneous conv areas

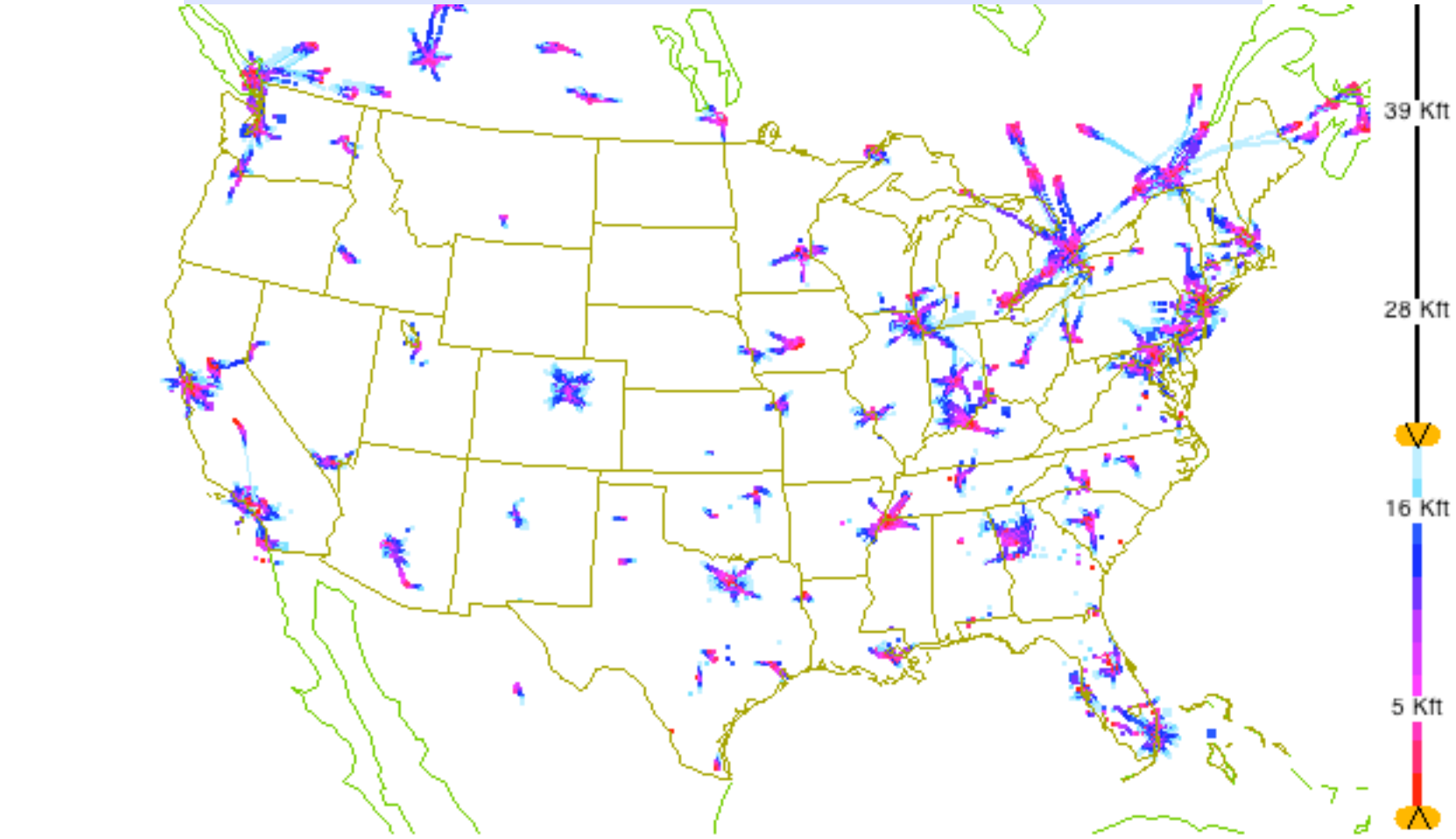
(On RUC assimilation of TAMDAR data) - AMDAR and TAMDAR definitions

- **"AMDAR" (Automated Meteorological Data and Recording) – are automatically sent from commercial aircraft, mostly large jets**

- **"TAMDAR" (Tropospheric AMDAR) – automatic reports from (currently) ~50 turboprops flying regionally in the US Midwest**
  - Provided by AirDat LLC
  - Agreement between Northwest Airlines (Mesaba – regional subsidiary) and AirDat LLC
  - New agreement between NWS/FAA and AirDat for use of TAMDAR

Aircraft reports below 20 Kft **without** TAMDAR

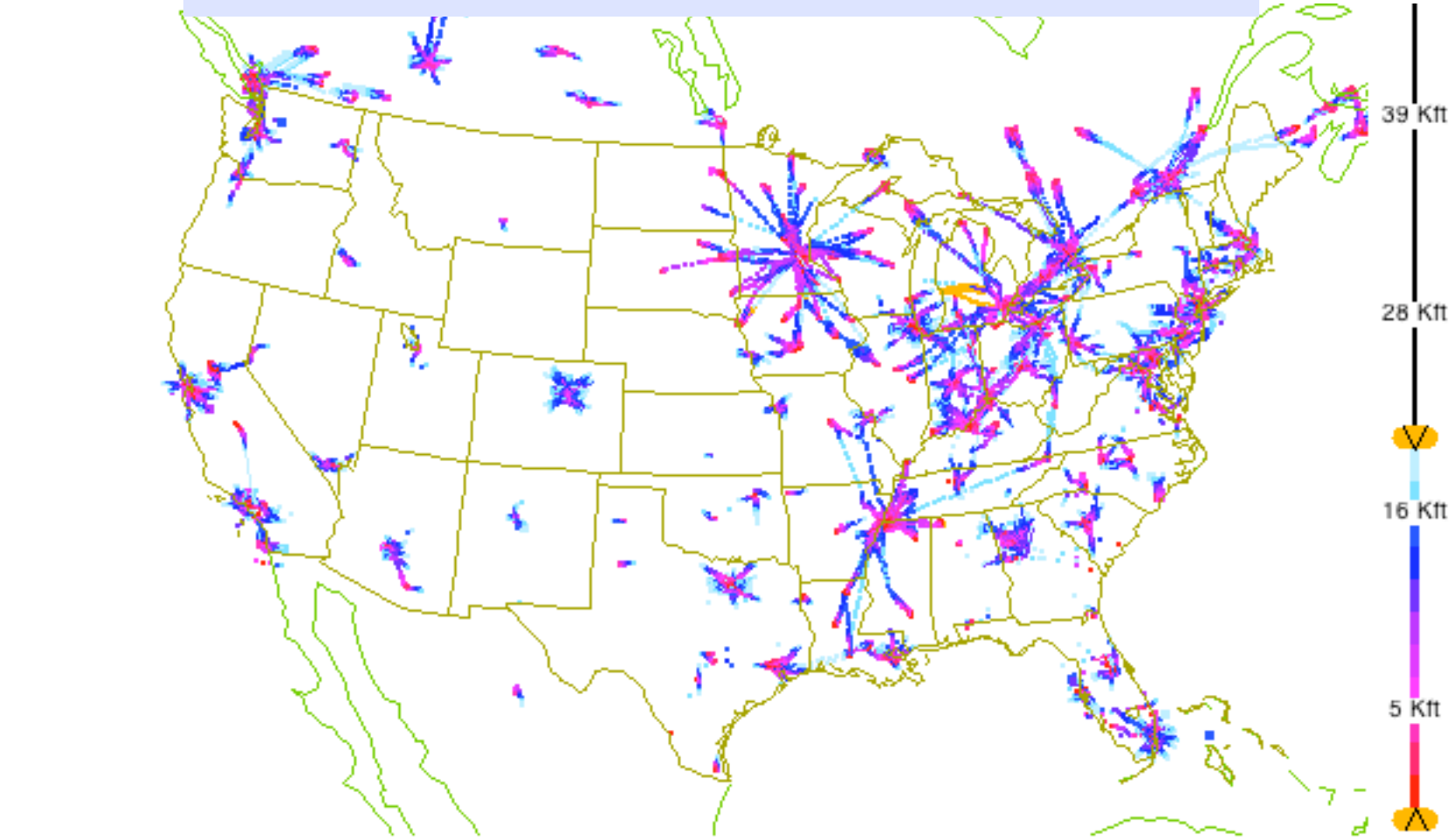
12-18z 9 October 2008



09-Oct-2008 12:00:00 -- 09-Oct-2008 17:59:59 (87152 obs loaded, 26951 in range, 5228 shown)

Aircraft reports below 20 Kft **including** TAMDAR

12-18z 9 October 2008



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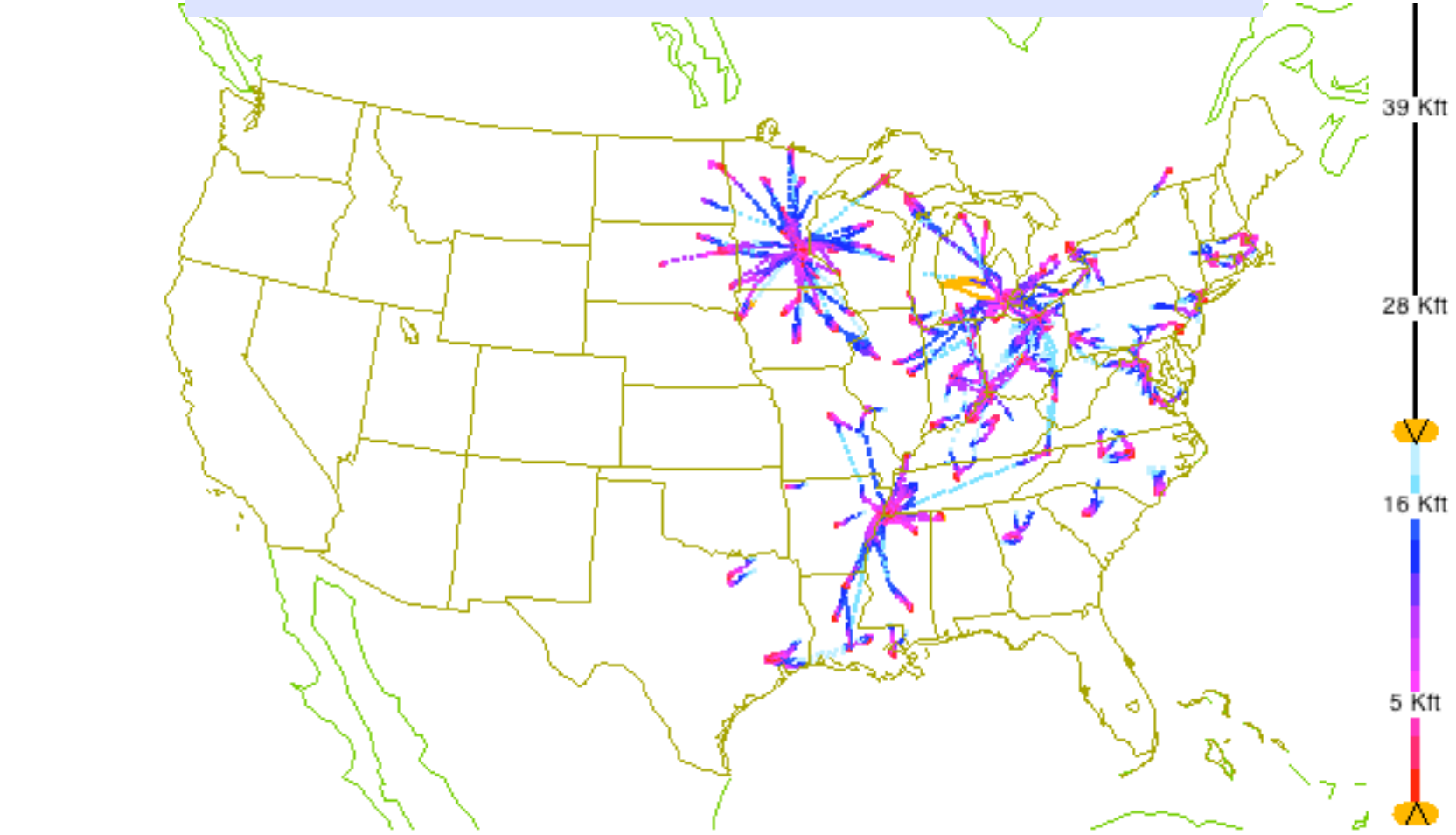
Aircraft reports below 20 Kft, **TAMDAR only**

12-18z 9 October 2008



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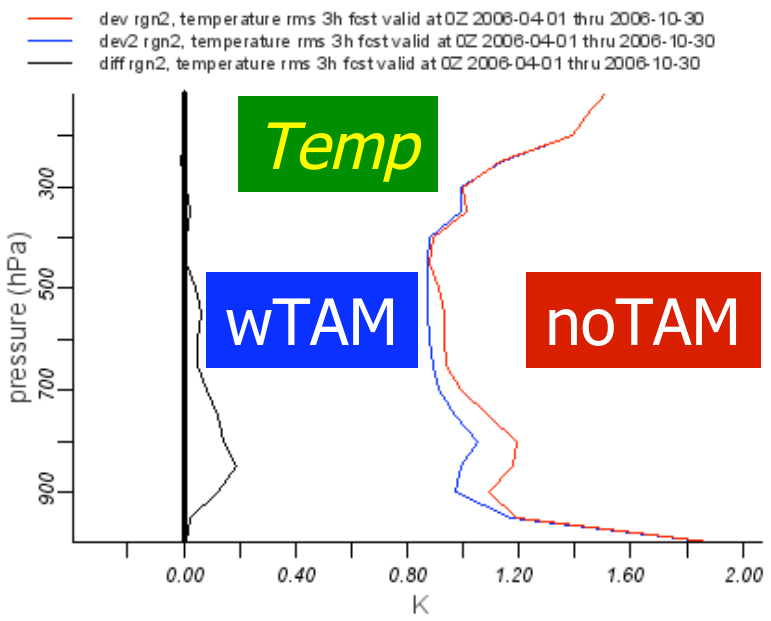
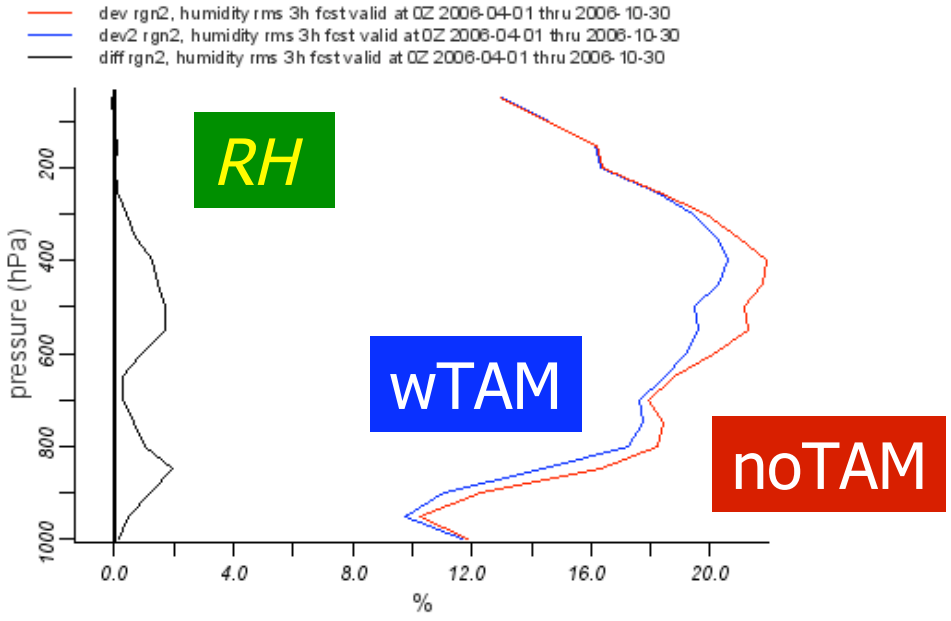
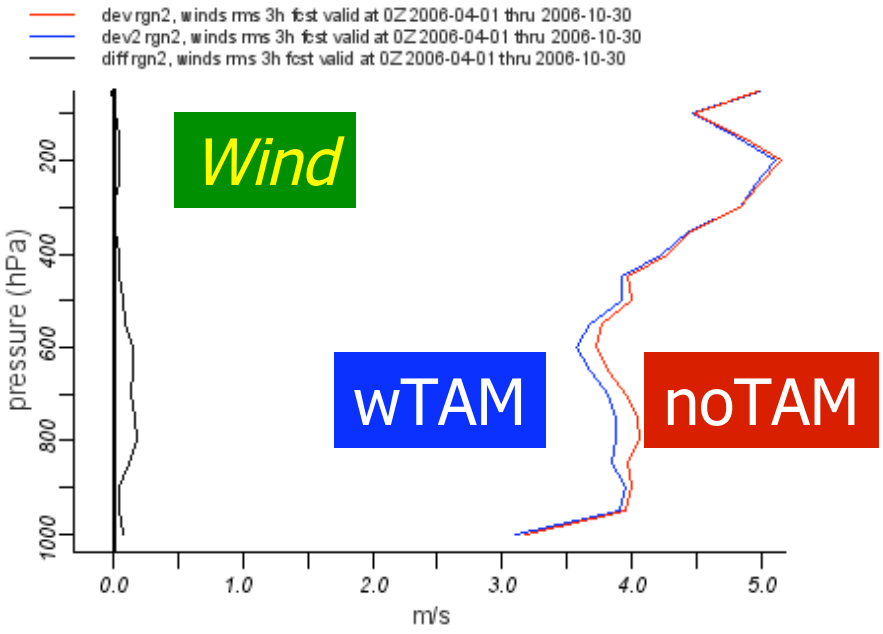
3h Fcst errors – RUCdev (no TAMDAR), RUCdev2 (w/ TAMDAR)







TAMDAR – regional aircraft with V/T/RH obs

GSD impact study with RUC parallel cycles

- 2005-2007 (ongoing)
- 10-30% reduction in RH, temperature, wind fcst error w/ TAMDAR assimilation

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  - Use of **radar reflectivity** in diabatic DFI in RUC model (also, hydrometeor assimilation component)
  - **Mesonet winds** using mesonet station uselist
  - **TAMDAR aircraft** observations
    (TAMDAR impact parallel RUC tests at GSD)
  - Higher obs error for moisture, wind observations
- Model physics
  - RRTM longwave radiation - eliminates sfc warm bias
  - Mod to Grell-Devenyi – decrease areal coverage
  - Mods to RUC land-sfc model
    - fresh snow density - nighttime temps over snow cover
    - limit on melting rate- allows warmer 2m temps
- Post-processing
  - add reflectivity fields, fixed land-sfc fields (as in NAM, GFS)
  - improved RTMA downscaling

RRTM Longwave Radiation in RUC Upgrade
Effect on 2-m temperature forecasts

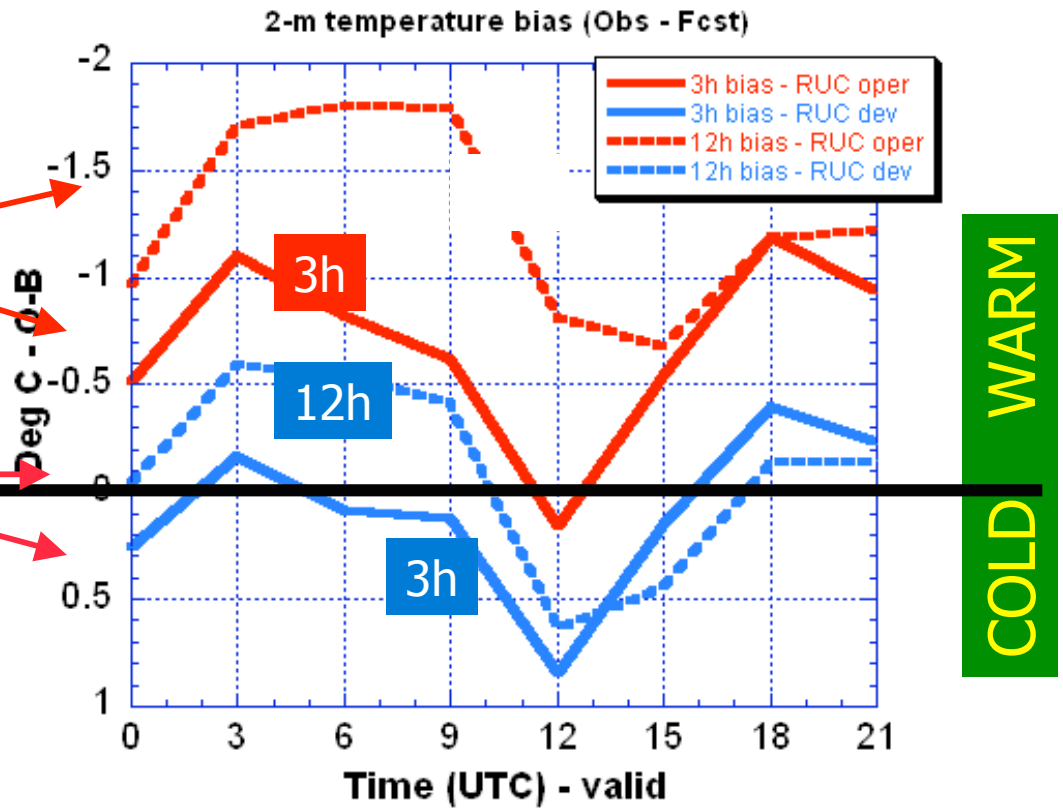
- Much decreased warm bias near surface

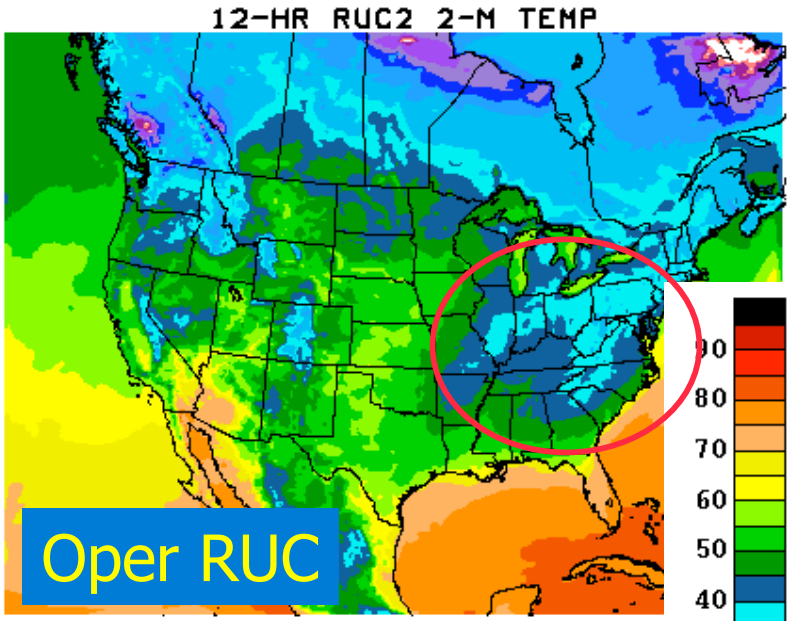
1-month comparison
14 May –13 June 07
Eastern US only

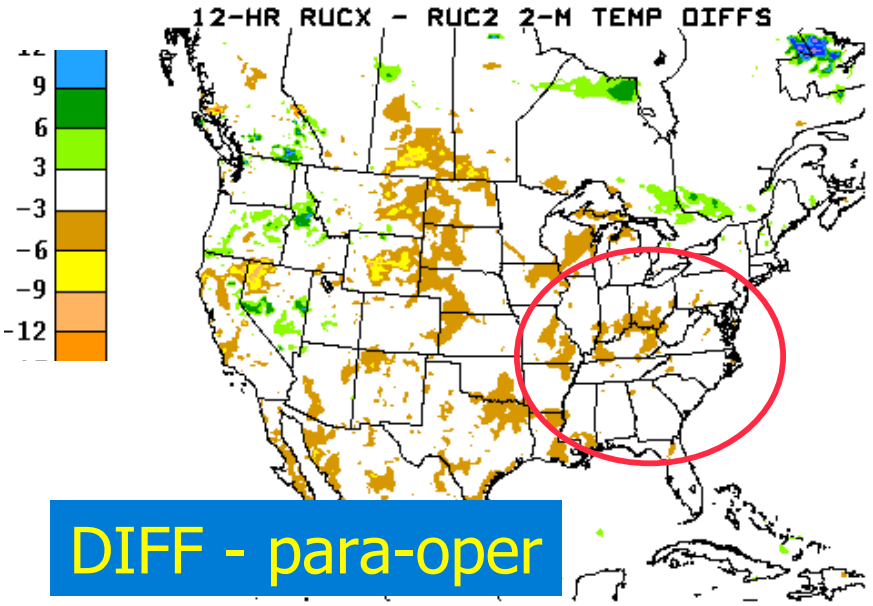
RUC oper – Dudhia LW

RUC para – RRTM LW

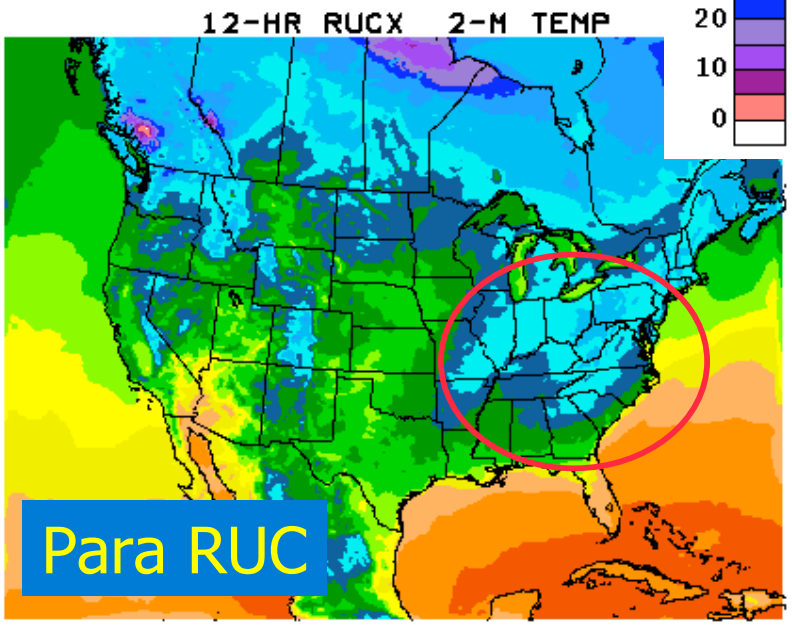
2-m temp bias (obs – forecast)

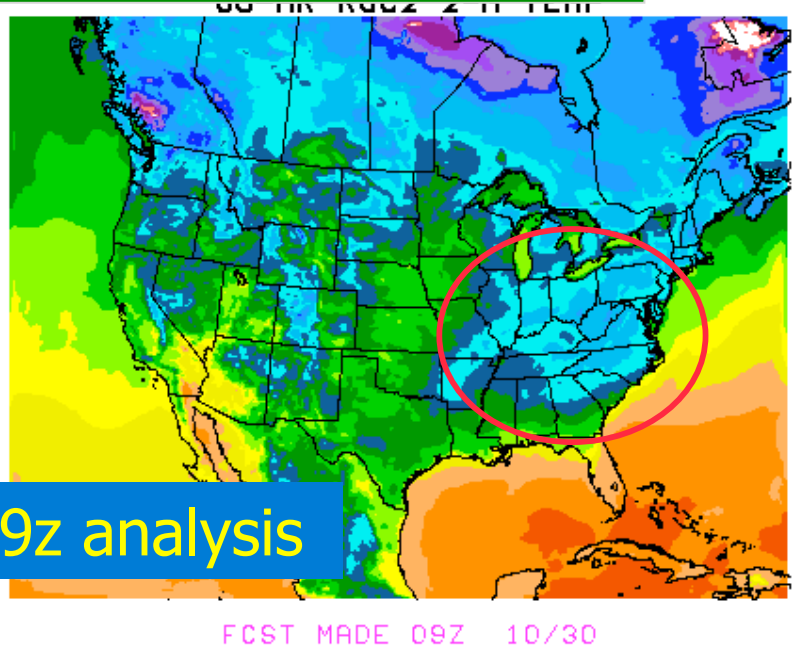






Better 2m temp forecast
From para RUC w/ RRTM LW





12h fcst – valid 09z 30 Oct

Grell-Devenyi Convection

Changes to address recent issues

Reduce weight given to Arakawa-Schubert closure
Result: Reduces the high spatial coverage bias of small amounts

Use smaller depth for cap adequate to deny convective initiation

Result: convection starts later in diurnal cycle

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    - limit on melting rate- allows warmer 2m temps
- Post-processing
  - add reflectivity fields, fixed land-sfc fields (as in NAM, GFS)
  - improved RTMA downscaling

Scientific results

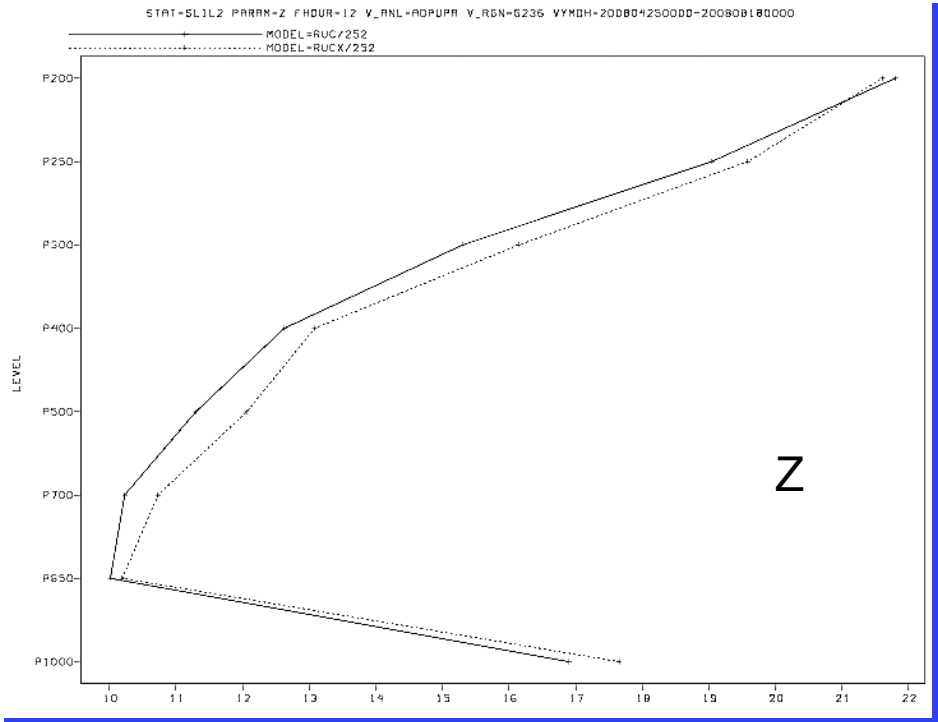
- ESRL/GSD – ongoing RUC parallel cycle with full radar reflectivity since March 2007
- EMC – ongoing parallel cycle since Aug 2007. Radar reflectivity availability became more reliable in Feb 2008

Following multi-month comparisons

- Summer 2008 - EMC
- Retrospective - Feb 2008 - EMC
- Real-time - Aug-current - NCO

FULL SUMMER PARALLEL

4/25/08 – 8/15/08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MODEL=RUC/252
MODEL=RUCX/252
LEVEL
P200
P250
P300
P400
P500
P700
P850
P1000
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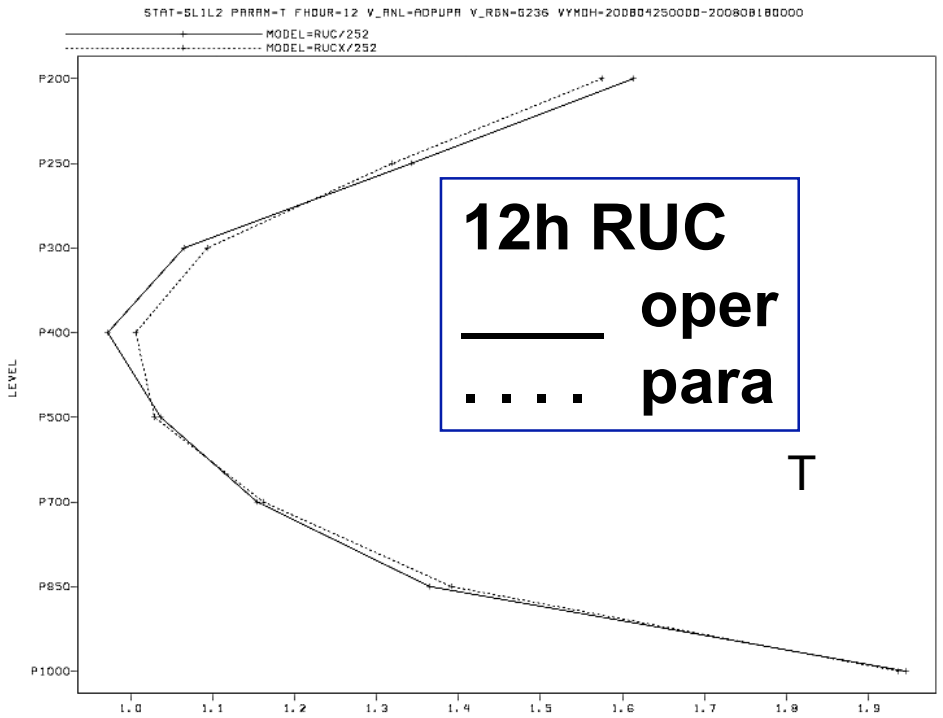
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MODEL=RUCX/252
LEVEL
P200
P250
P300
P400
P500
P700
P850
P1000
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12h RUC
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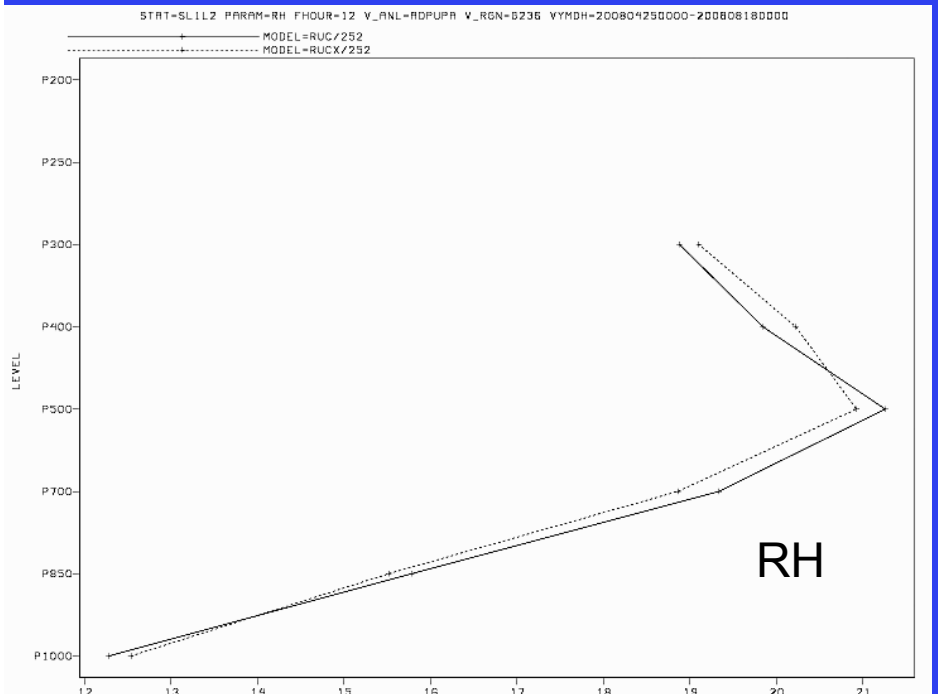
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MODEL=RUCX/252
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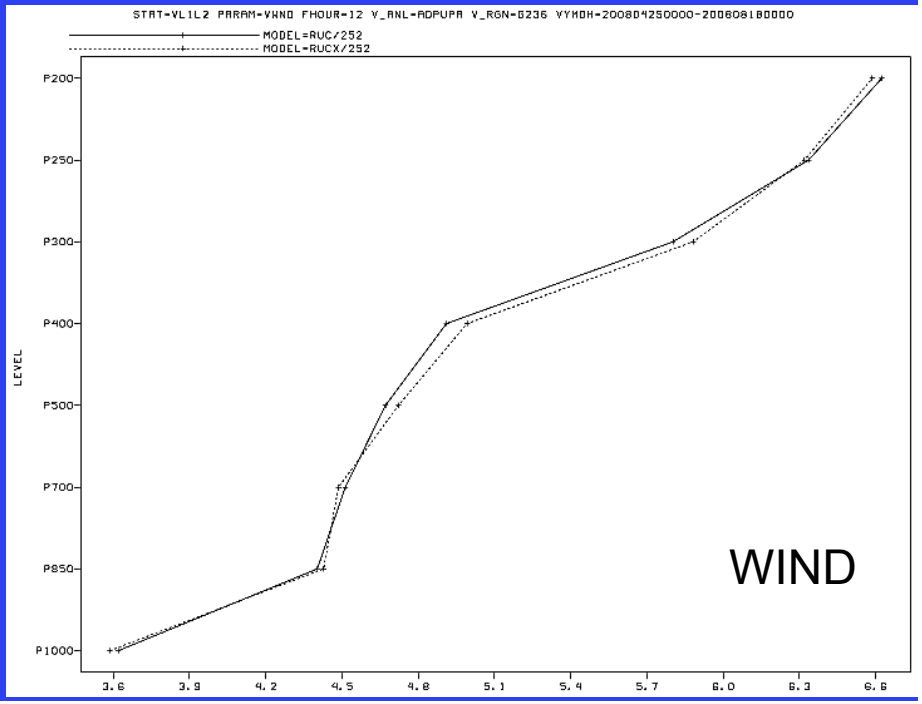
P250
P300
P400
P500
P700
P850
P1000
RH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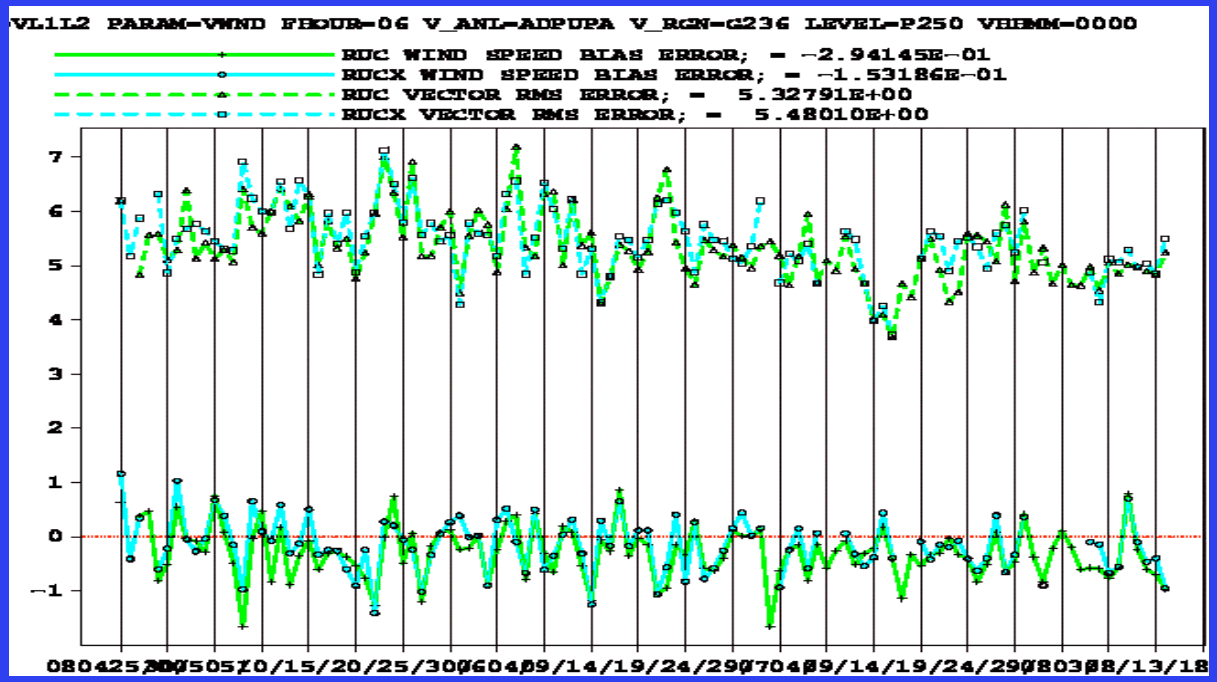
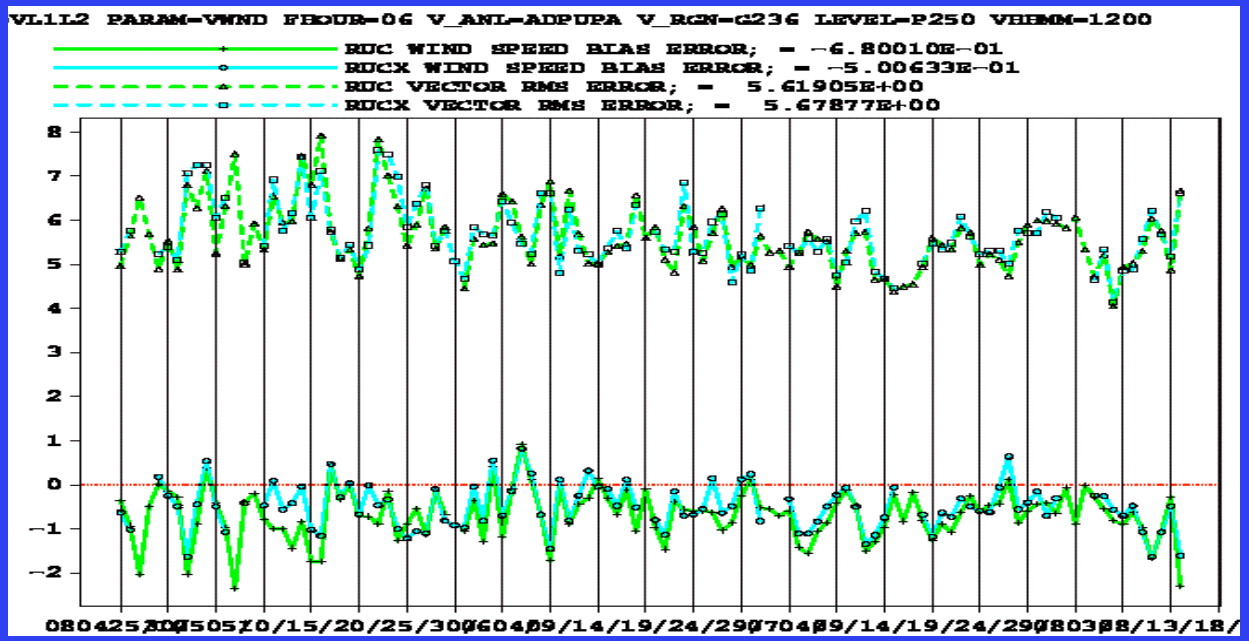
MODEL=RUC/252
MODEL=RUCX/252
LEVEL
P200
P250
P300
P400
P500
P700
P850
P1000
3.6
3.9
4.2
4.5
4.8
5.1
5.4
5.7
6.0
6.3
6.6
WIND

Valid
00z

6-hr fcsts
250 mb winds



Valid
12z



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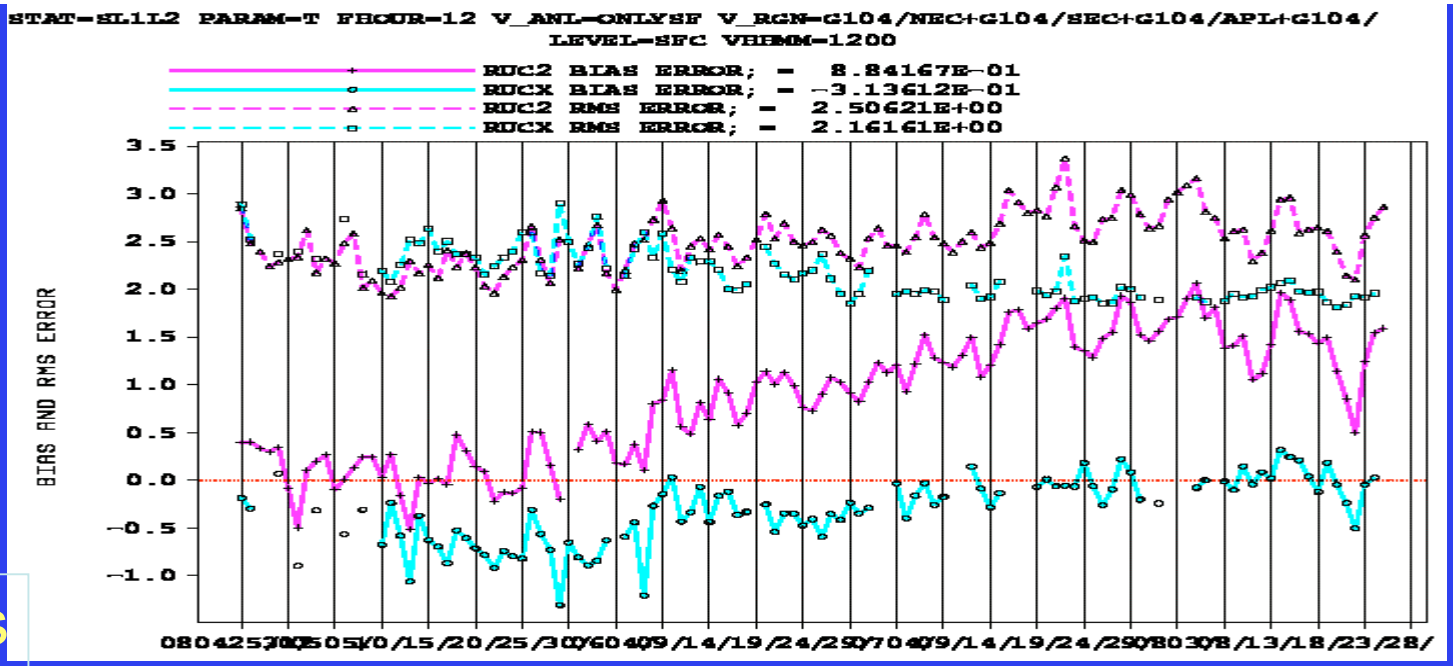
12h fcsts - Valid 12z



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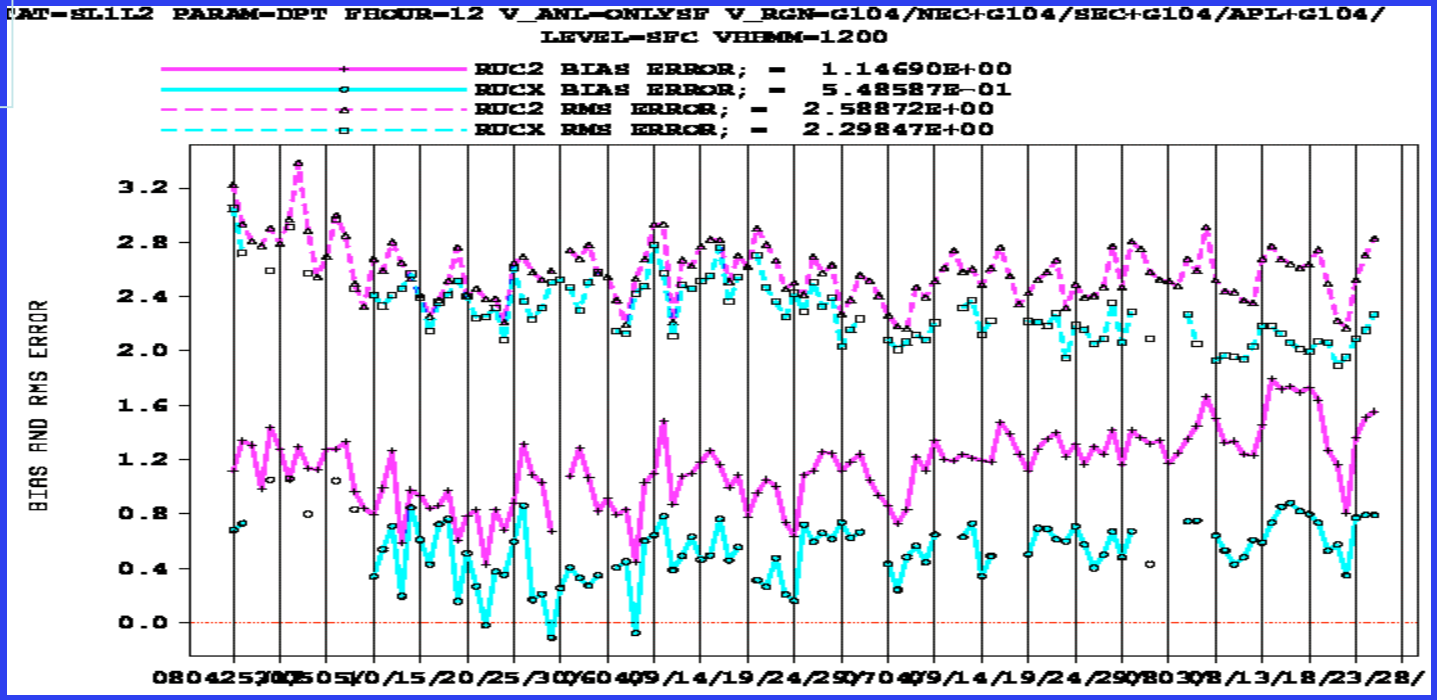
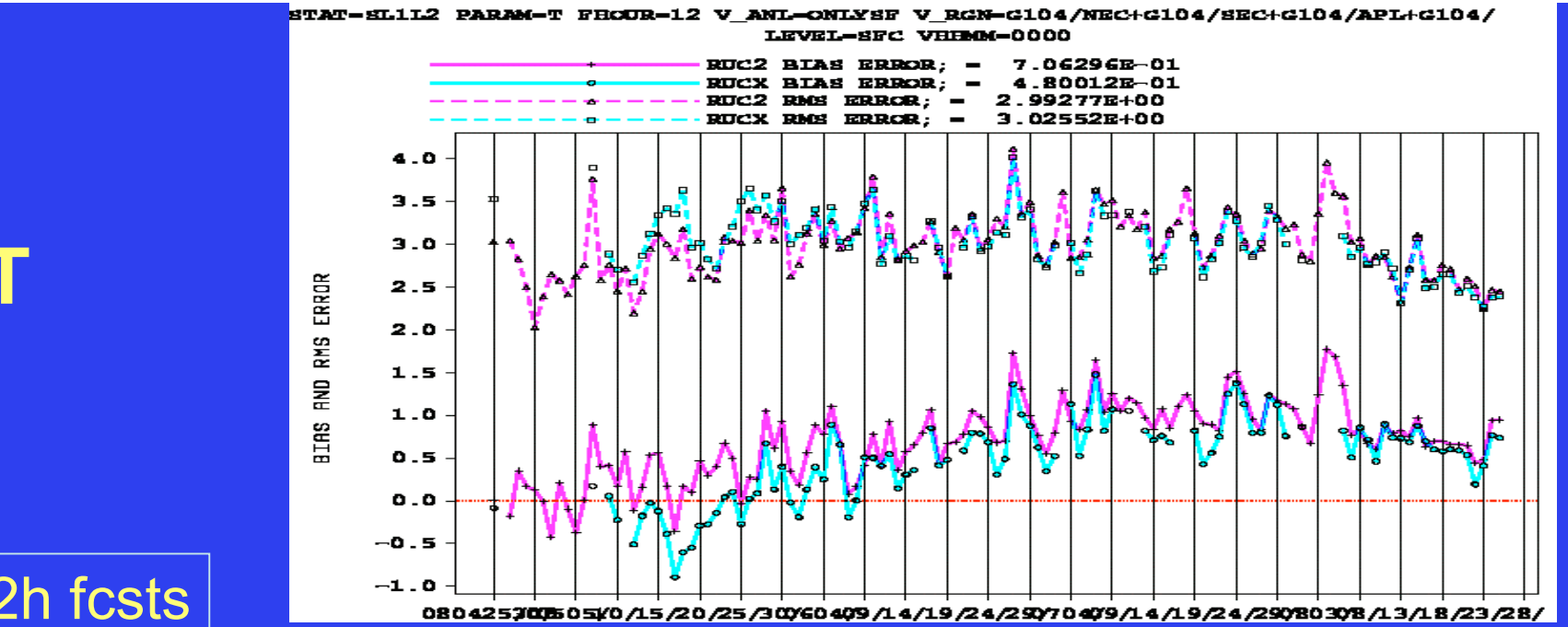
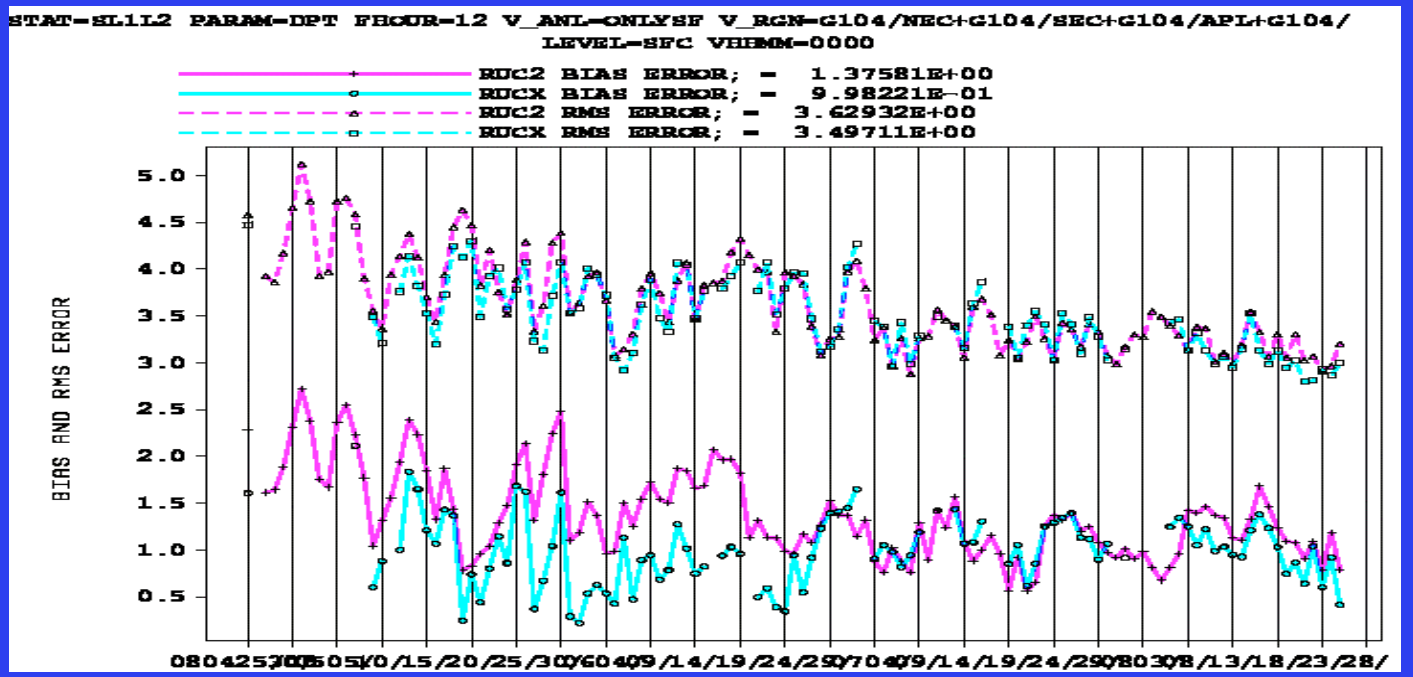


T

12h fcsts - Valid 00z

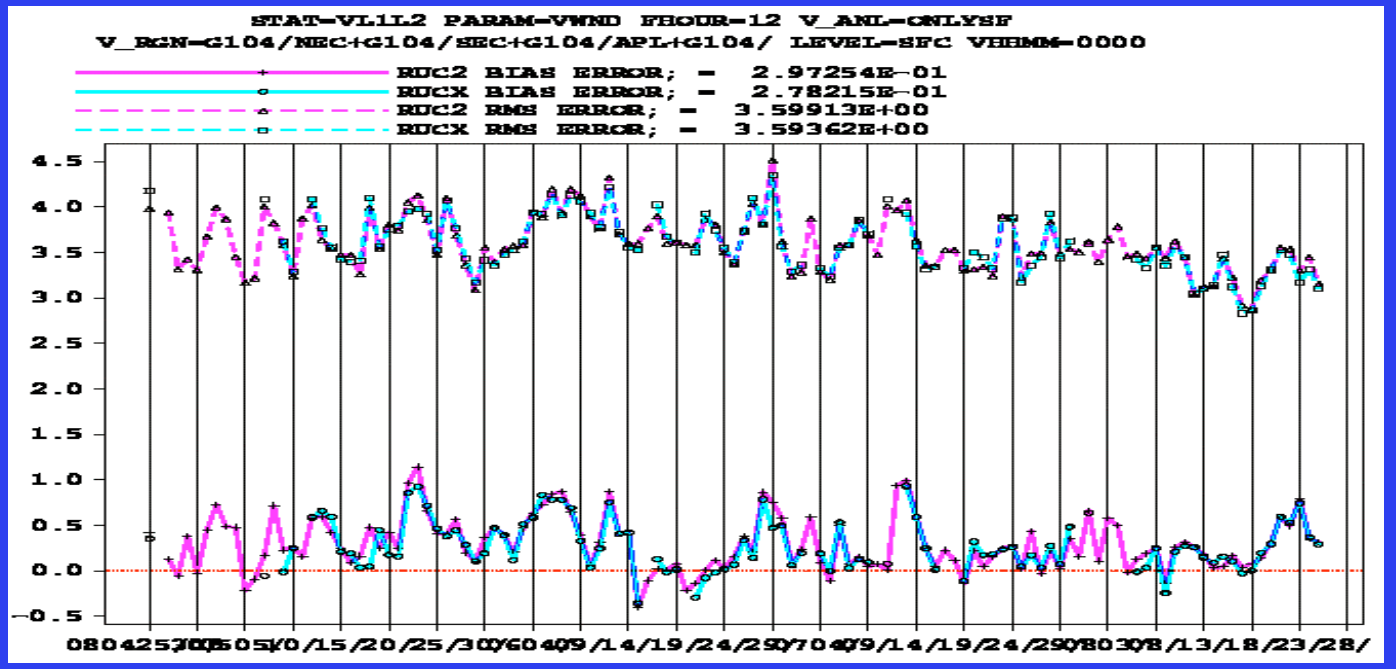
Td



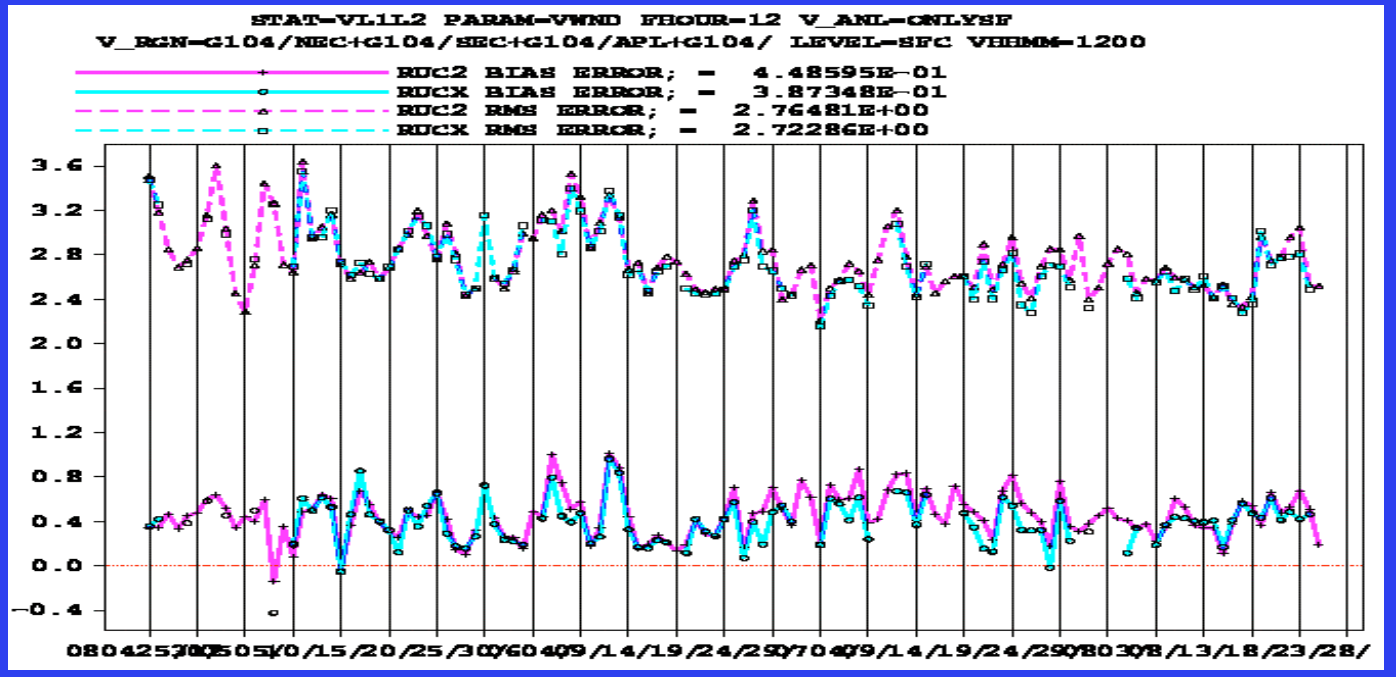


Valid
00z

10-m
WIND
- 12h fcsts

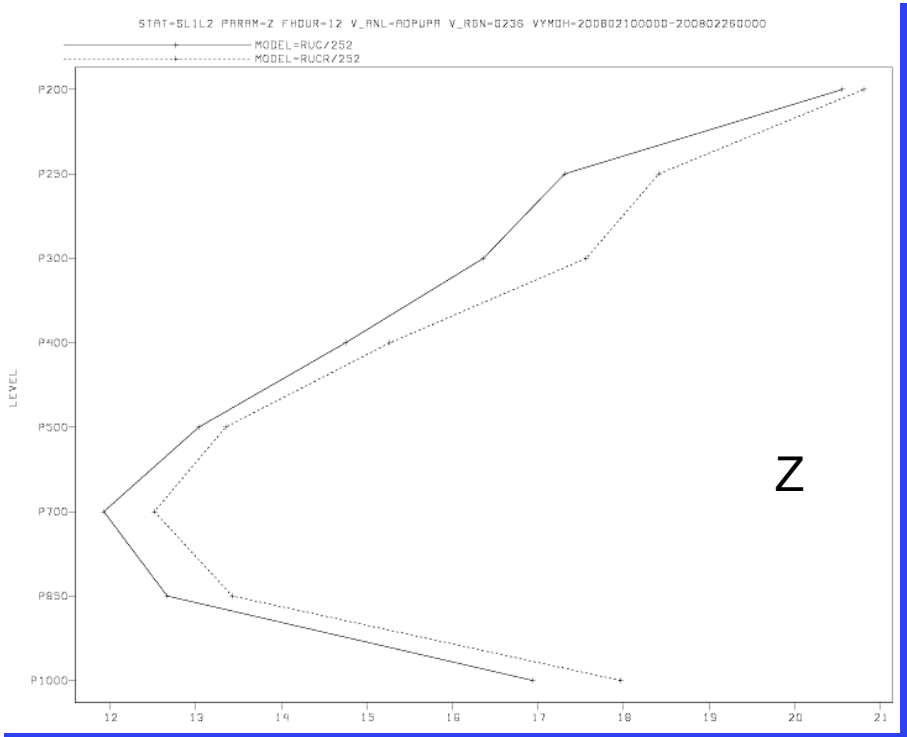


Valid
12z



Retrospective Stats

2/10-08 – 2/25/08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P200
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21
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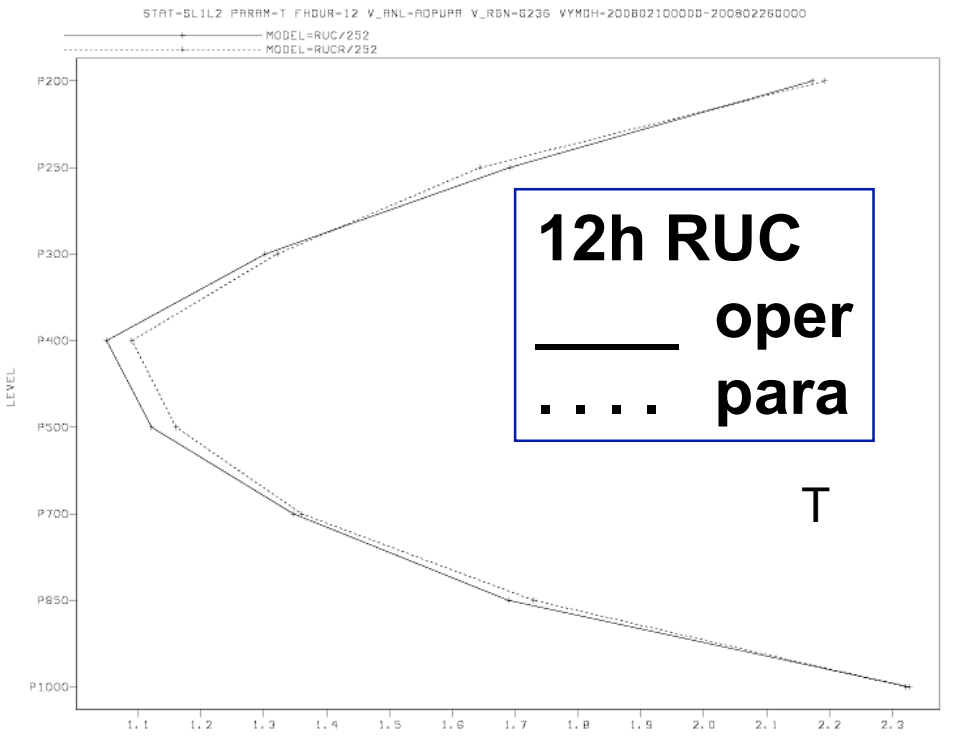
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1.3
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1.5
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2.1
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2.3
12h RUC
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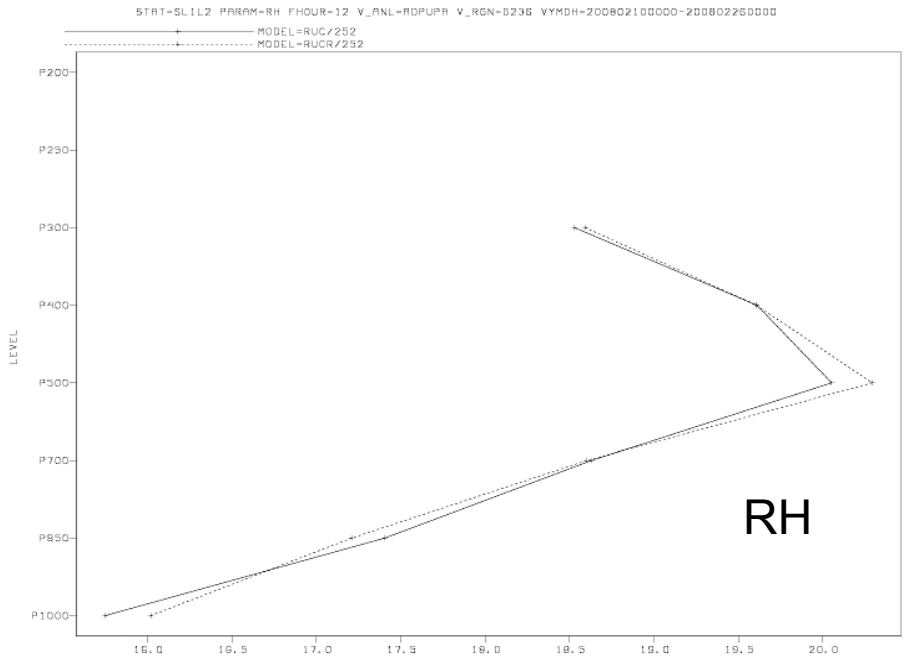
T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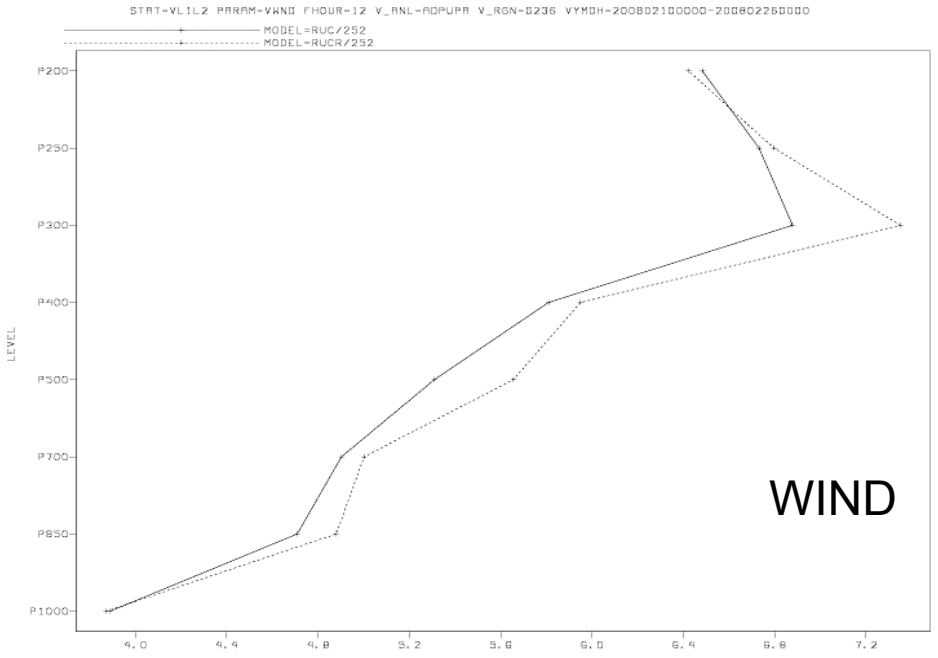
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P700
P850
P1000
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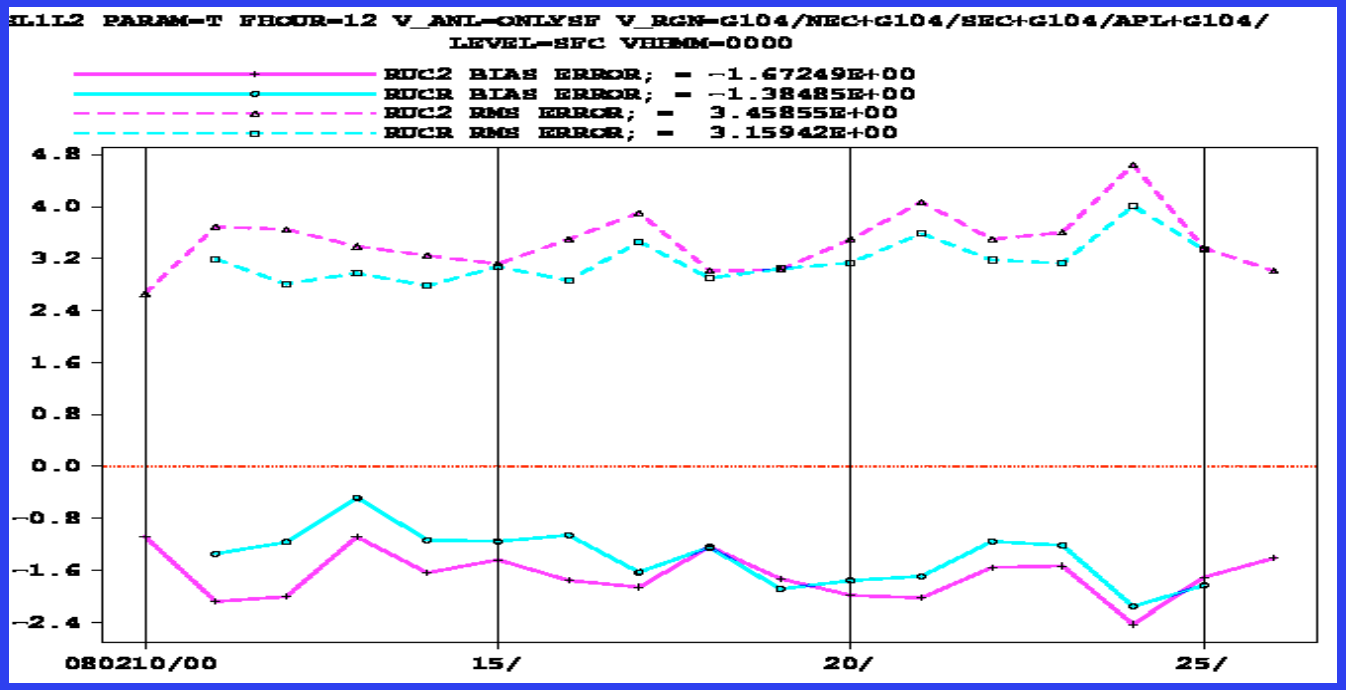
7.2
WIND

Valid
00z

12h fcsts
- 2m temps



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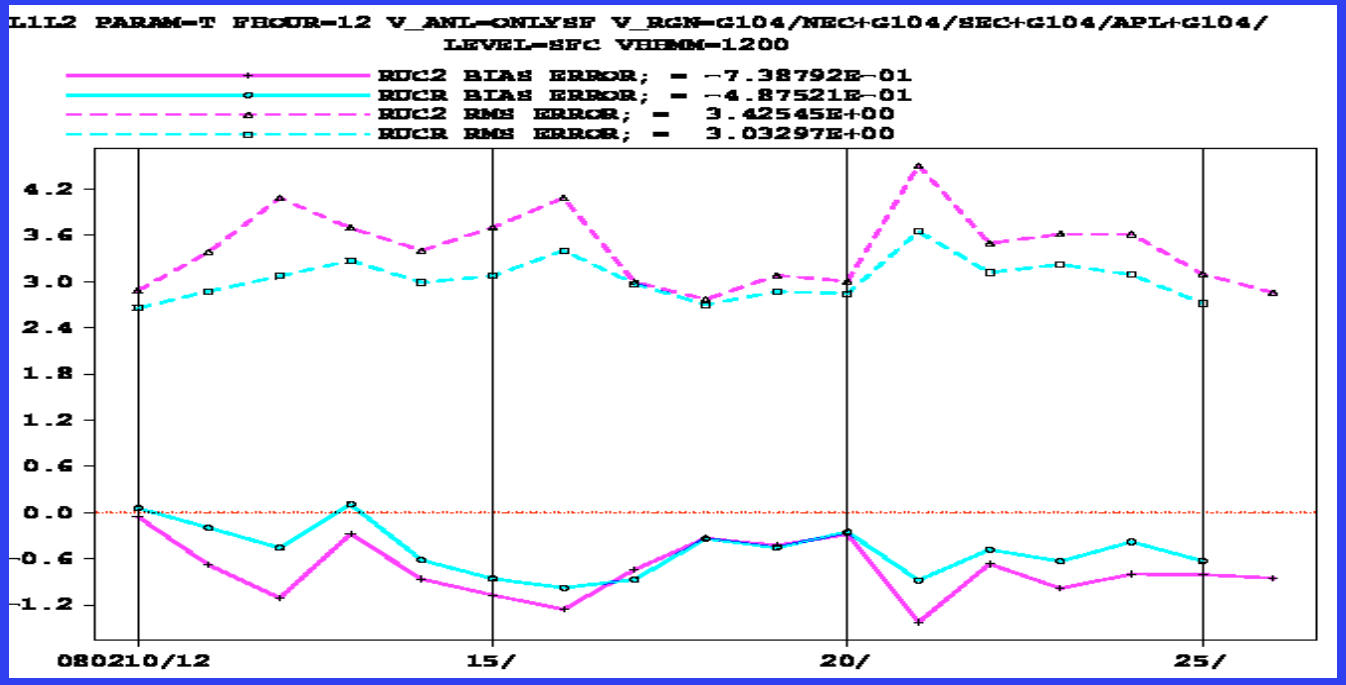
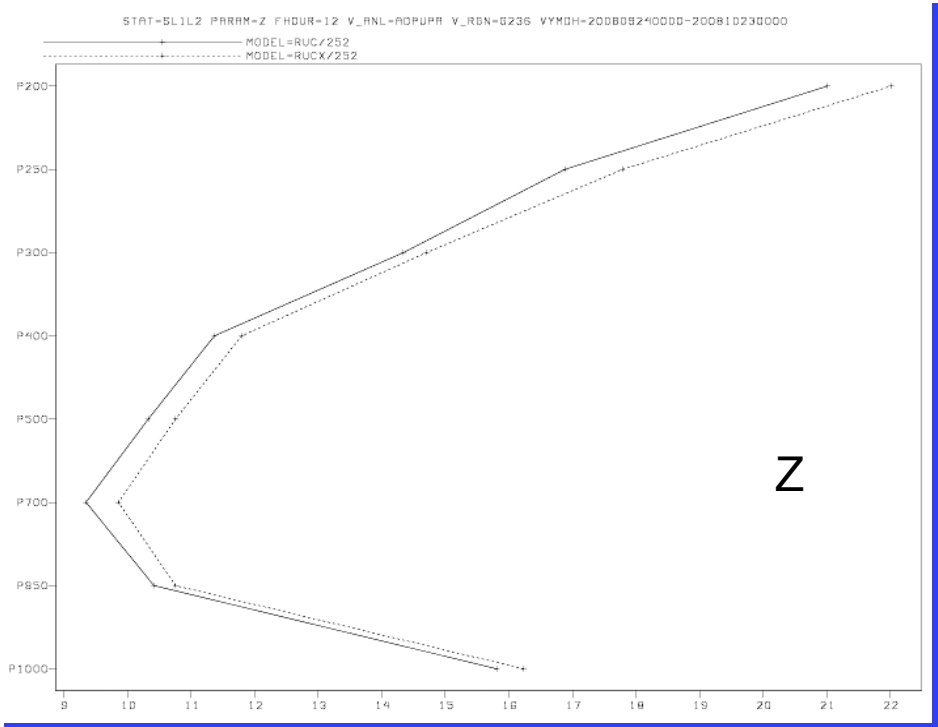


NCO Parallel Stats

9/25/08 – 10/24/08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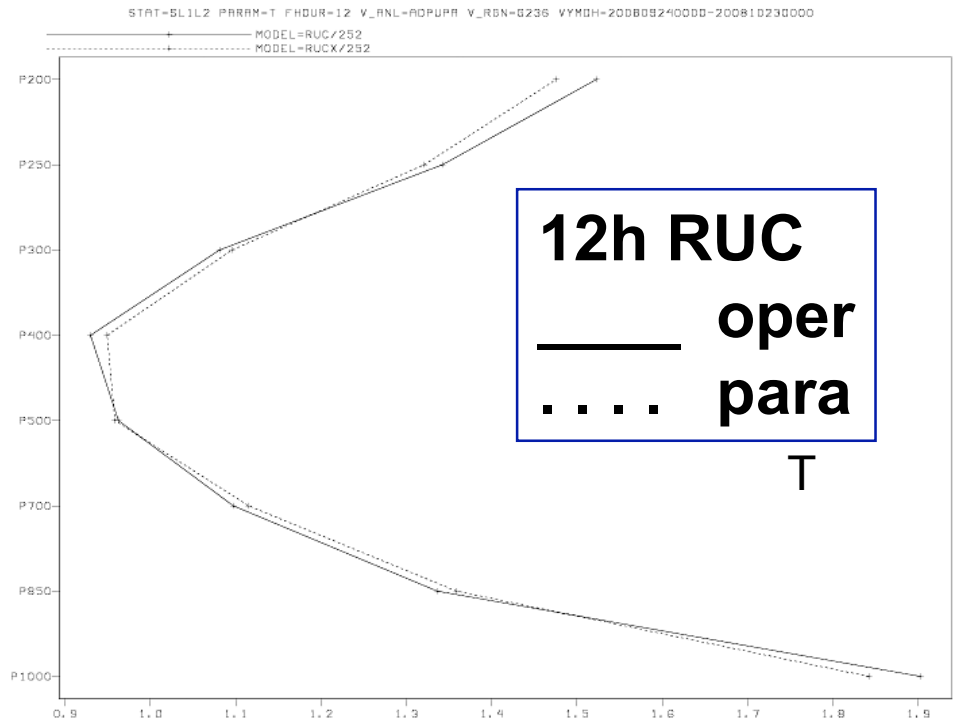
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12h RUC
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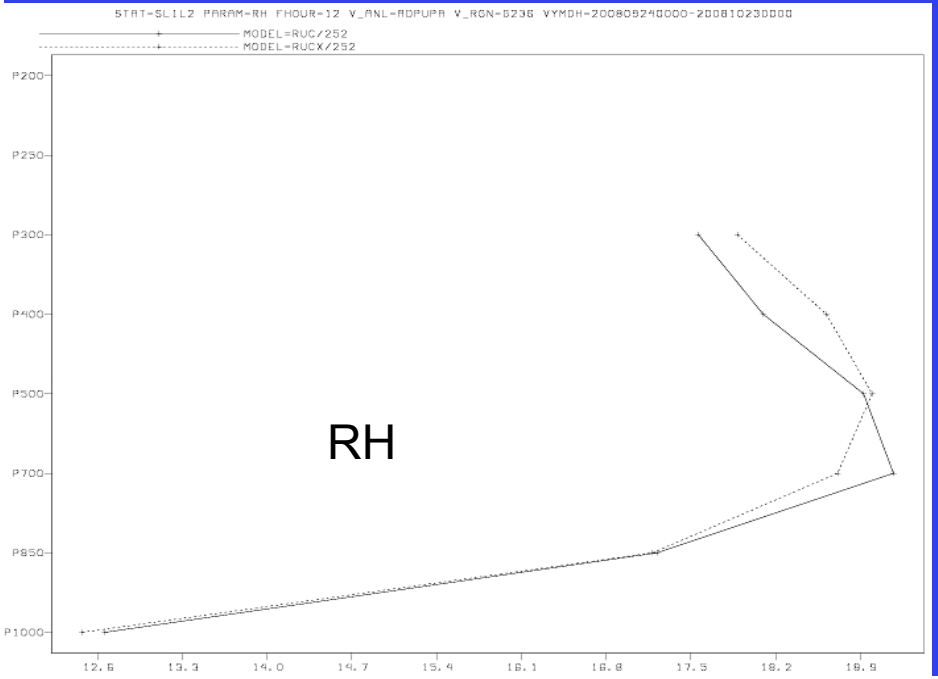
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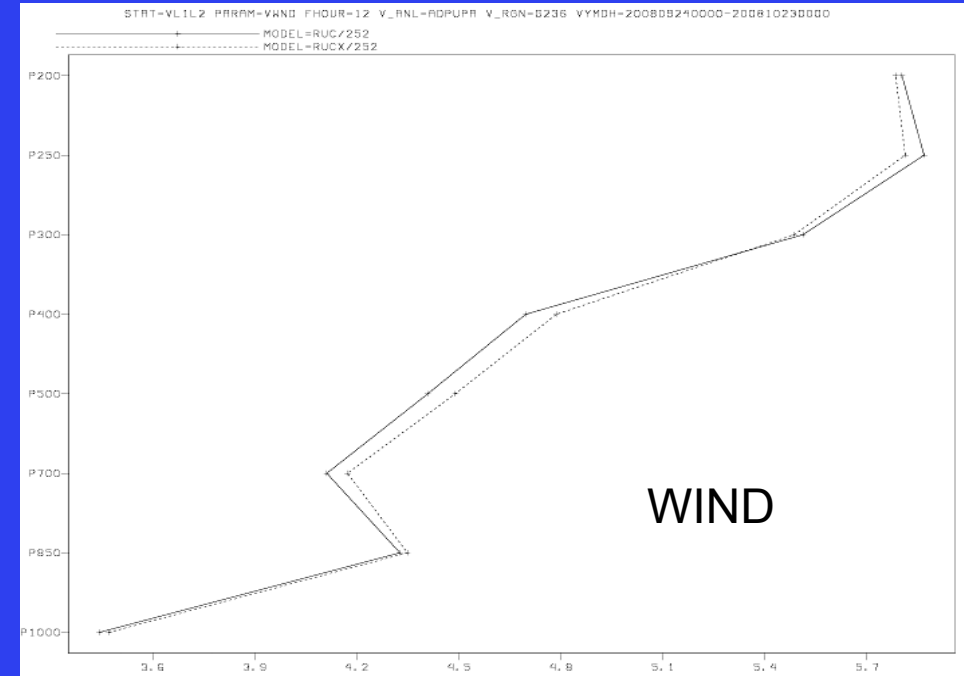
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P500
P700
P850
P1000
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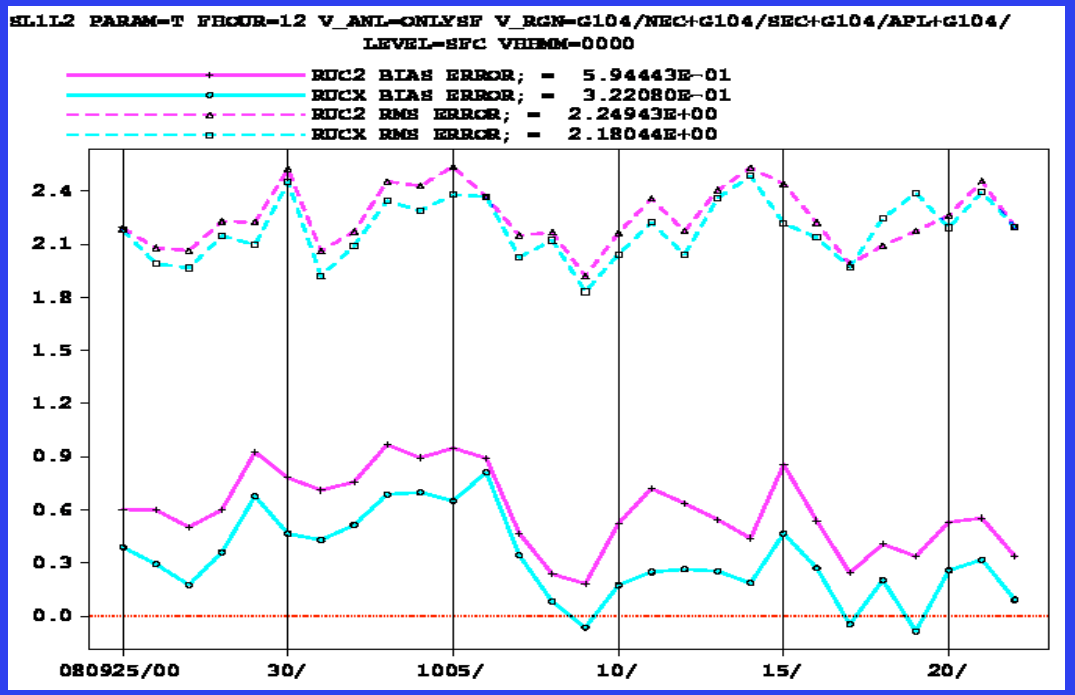
3.9
4.2
4.5
4.8
5.1
5.4
5.7
WIND

Valid
00z

12h fcsts
- 2m temps



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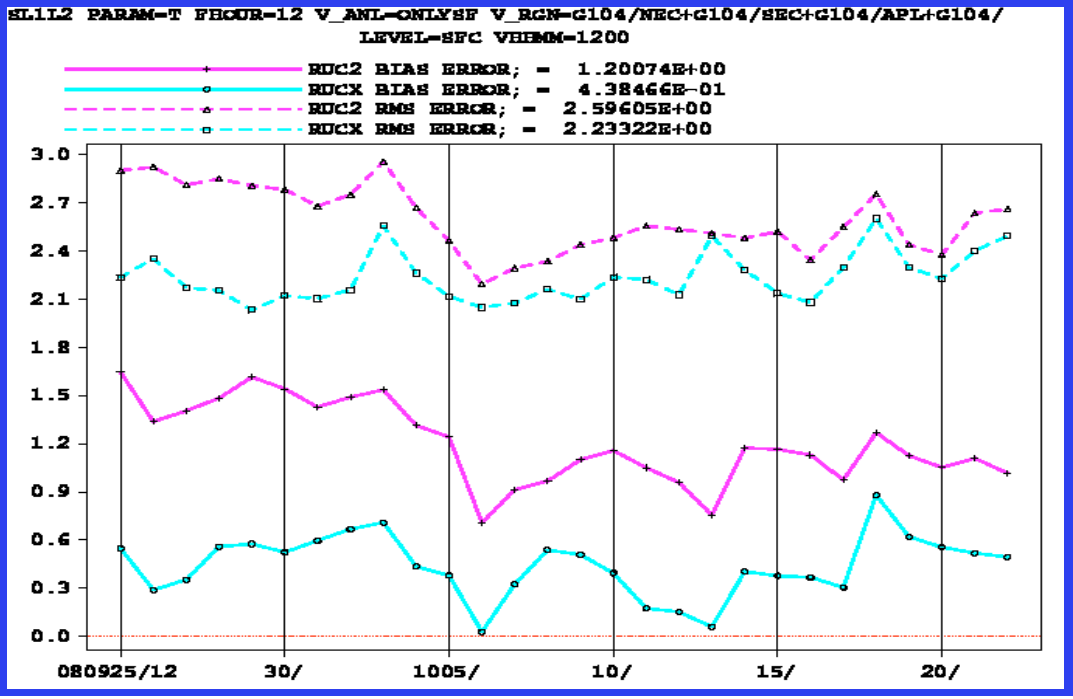
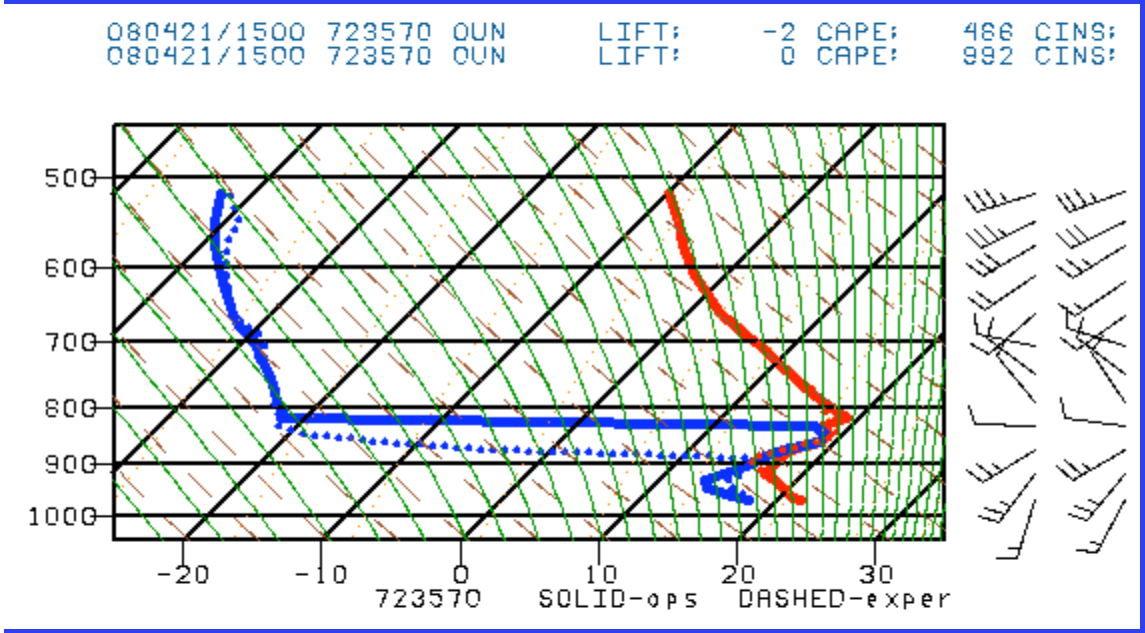
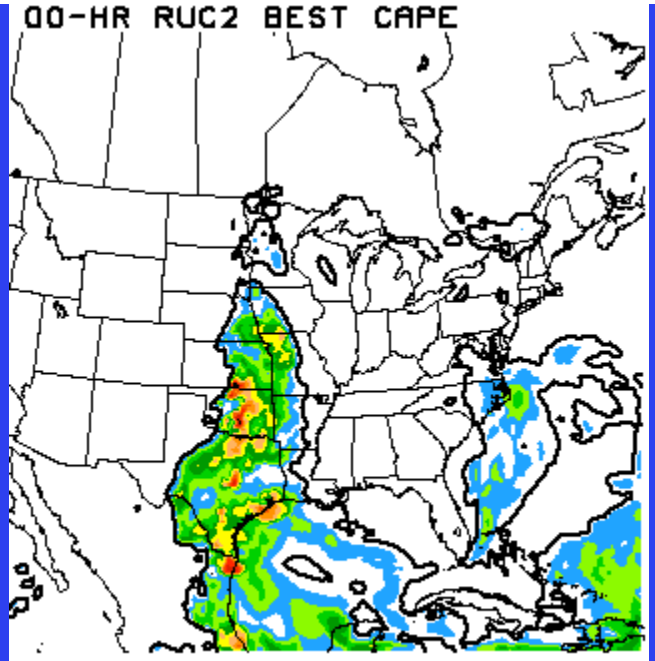
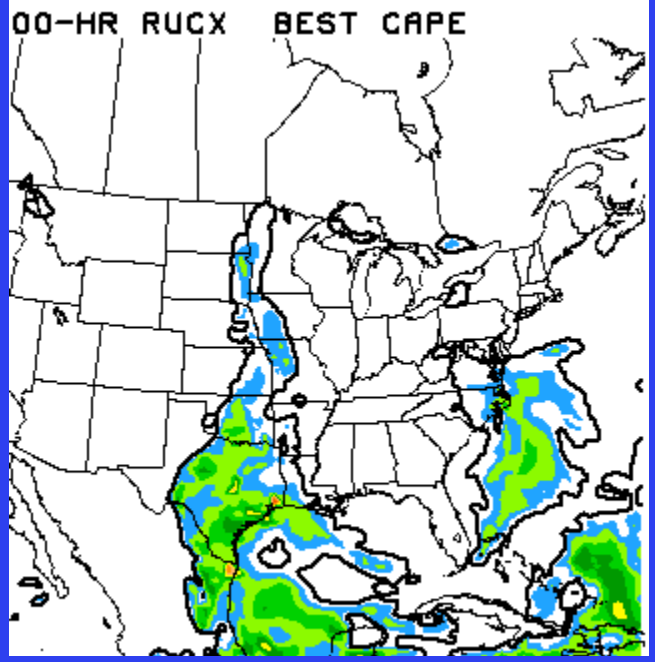
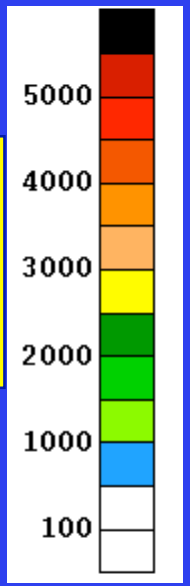


CASES

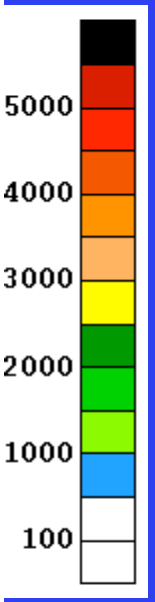


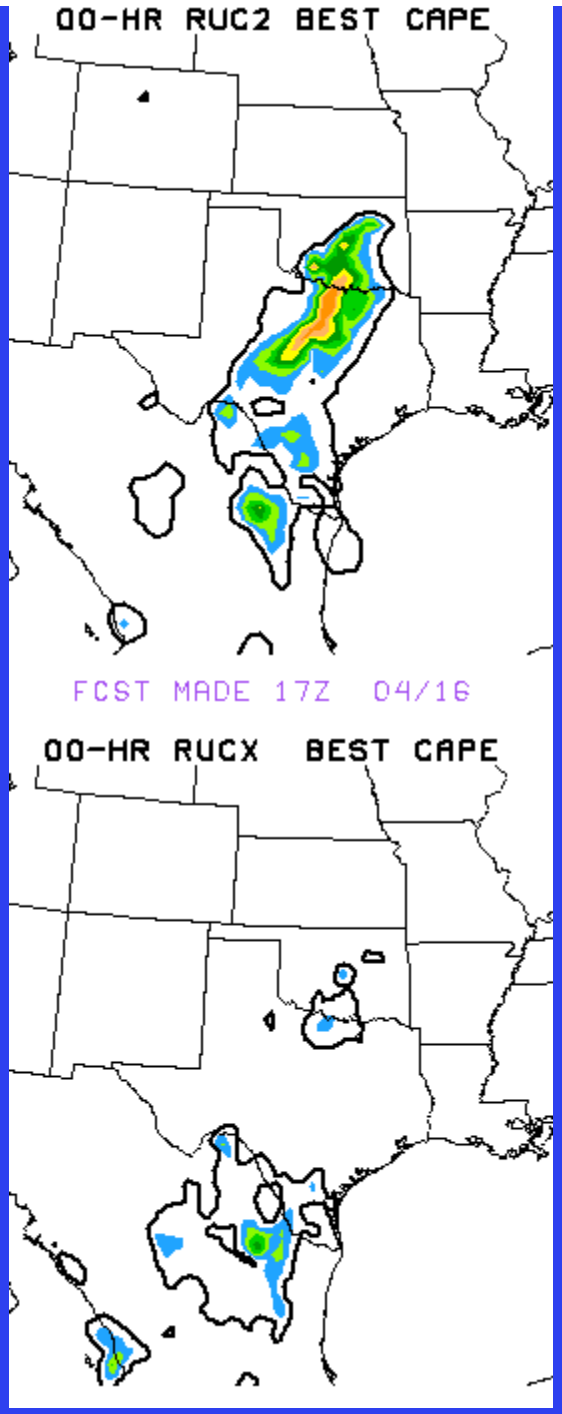


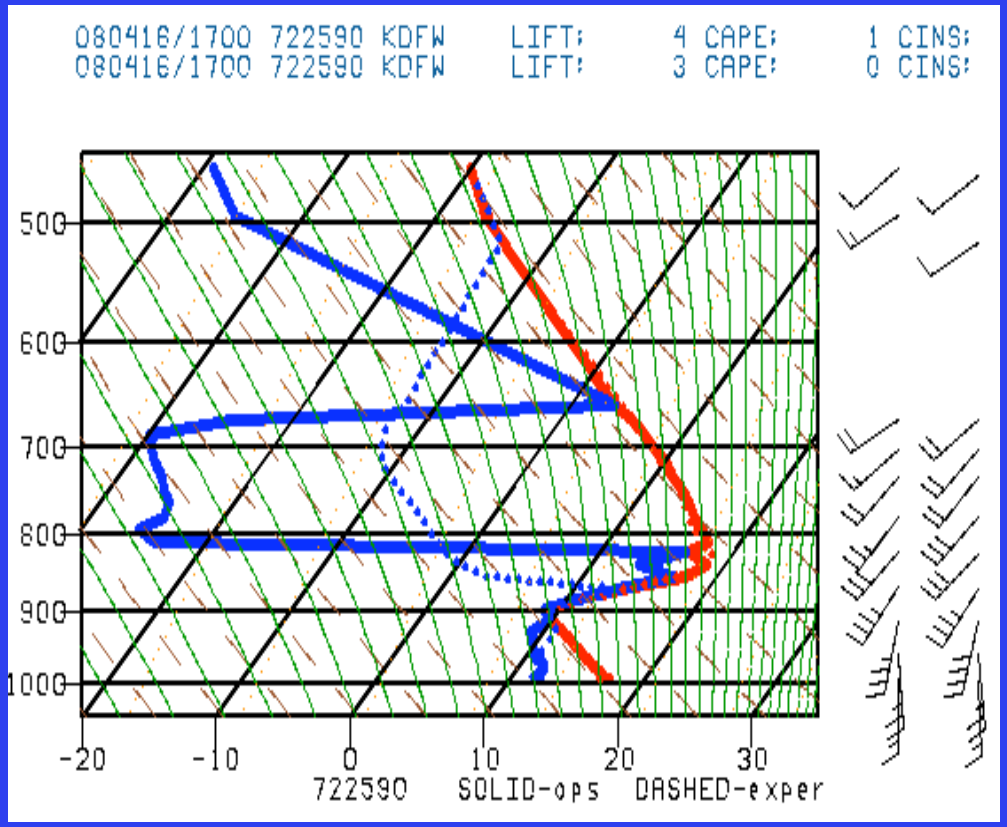




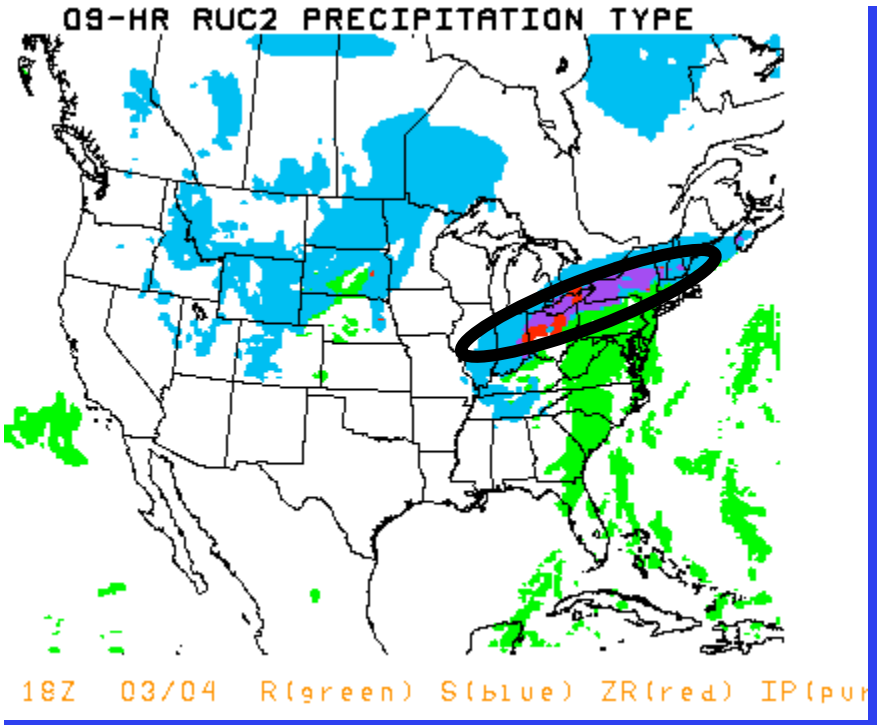
Effect of mods to moisture background error covariance in RUC 3dvar, higher obs error

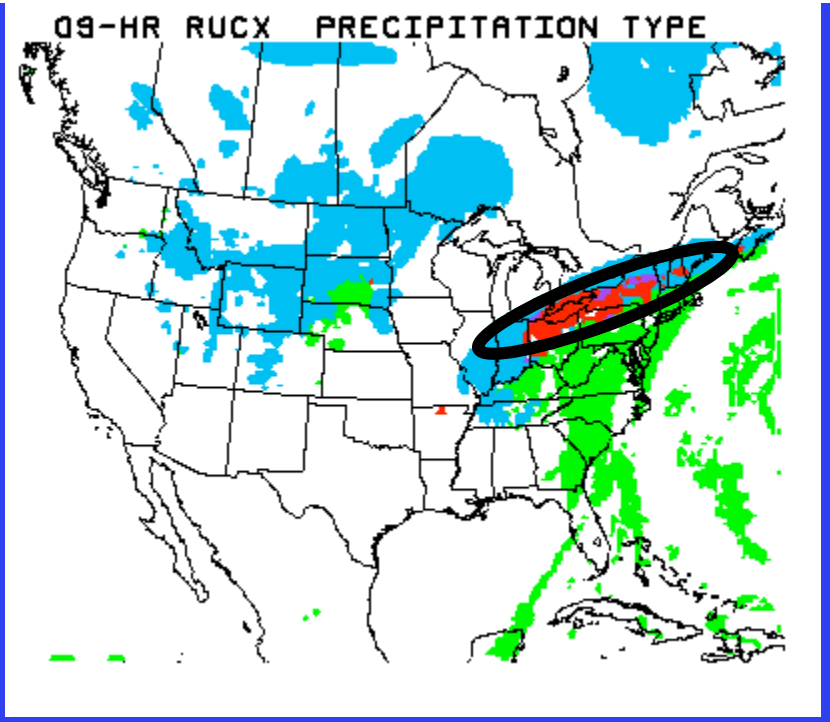




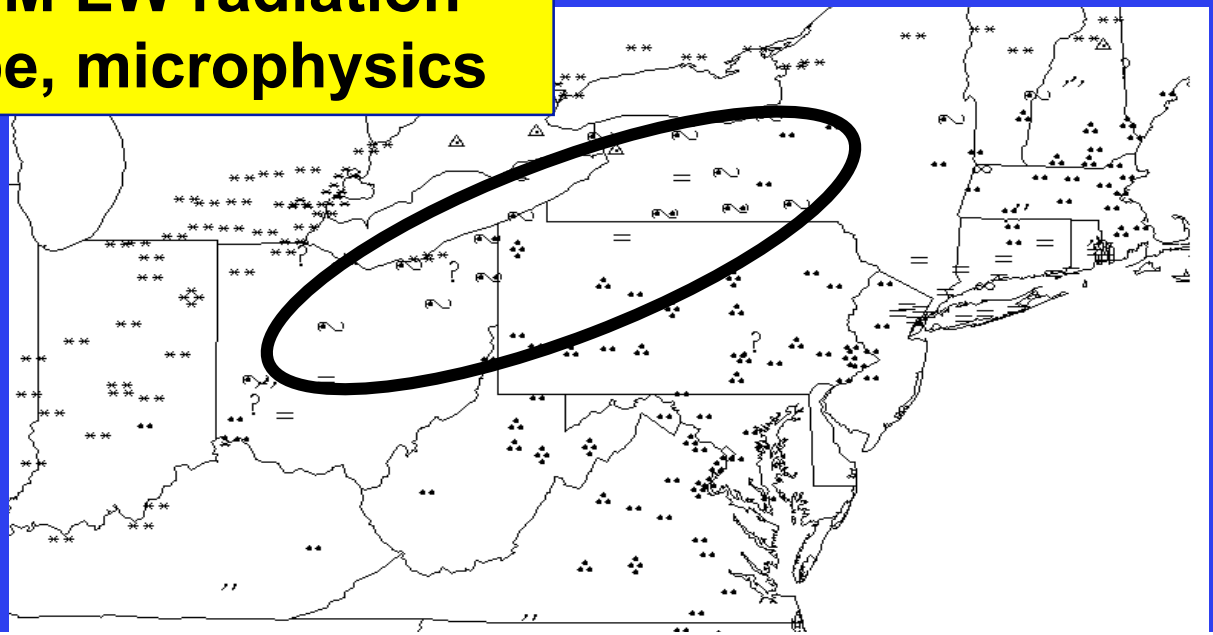


Effect of mods to moisture bkg error covariance in RUC 3dvar

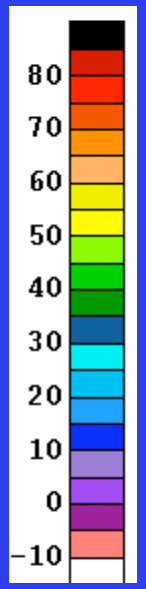


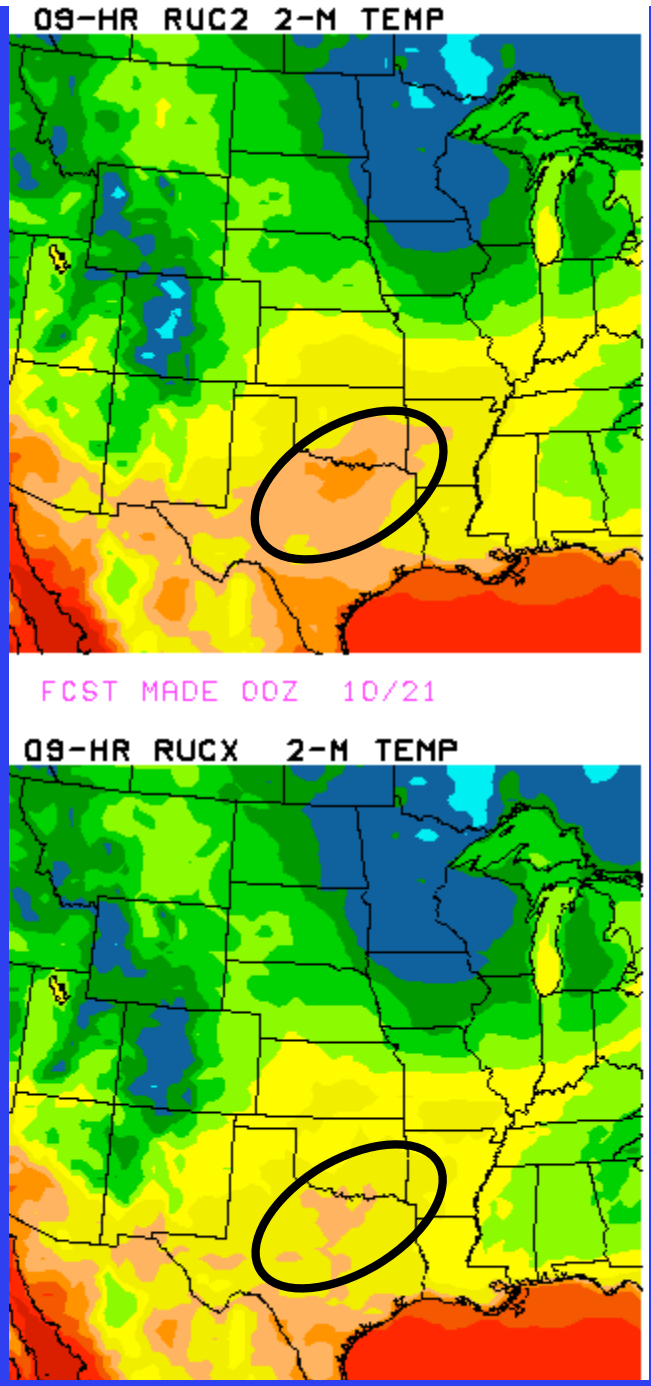


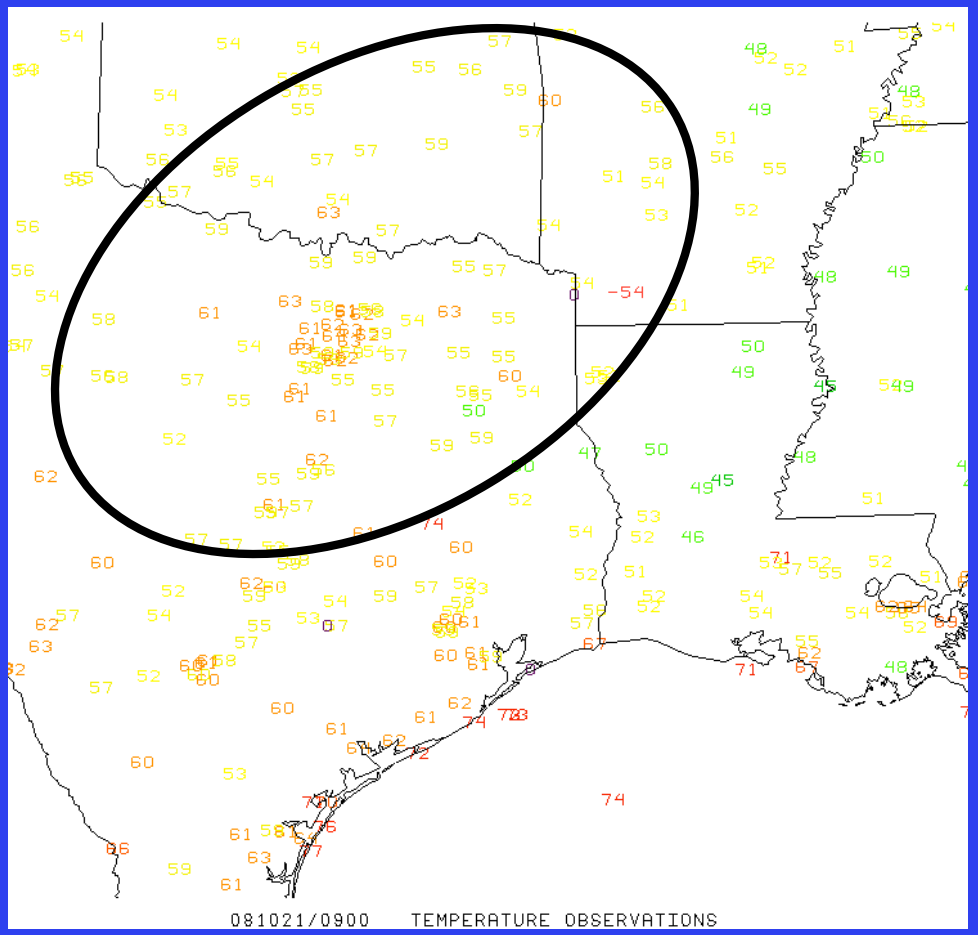
Effect of RRTM LW radiation on precip-type, microphysics

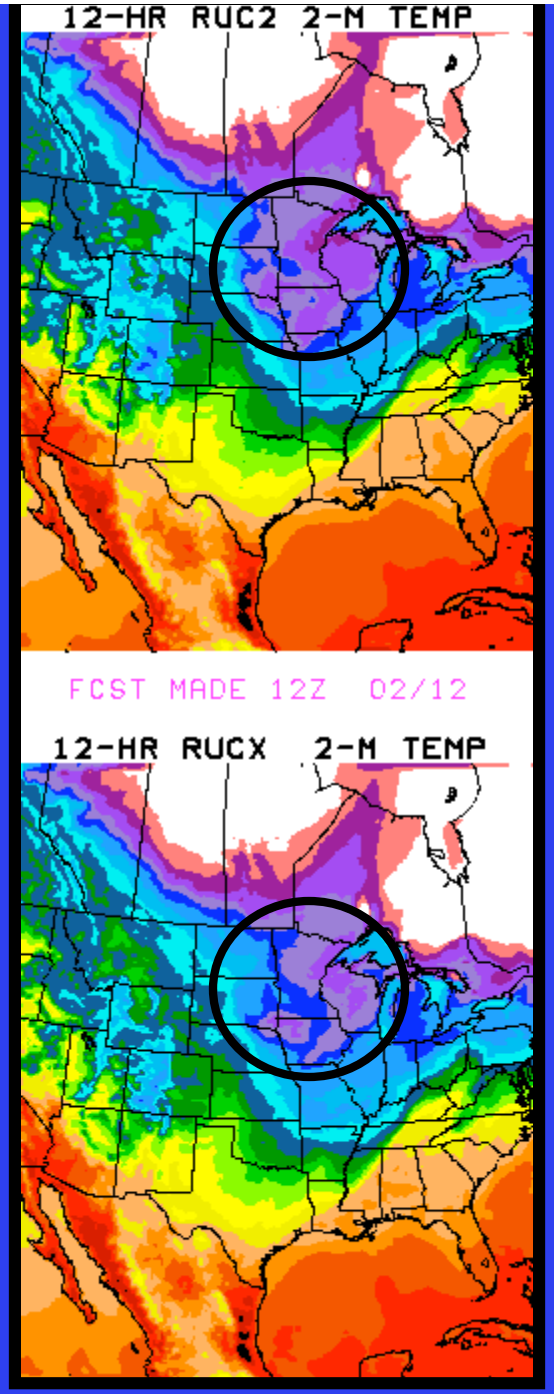


Effect of RRTM LW radiation on 2m temp, reduced warm bias

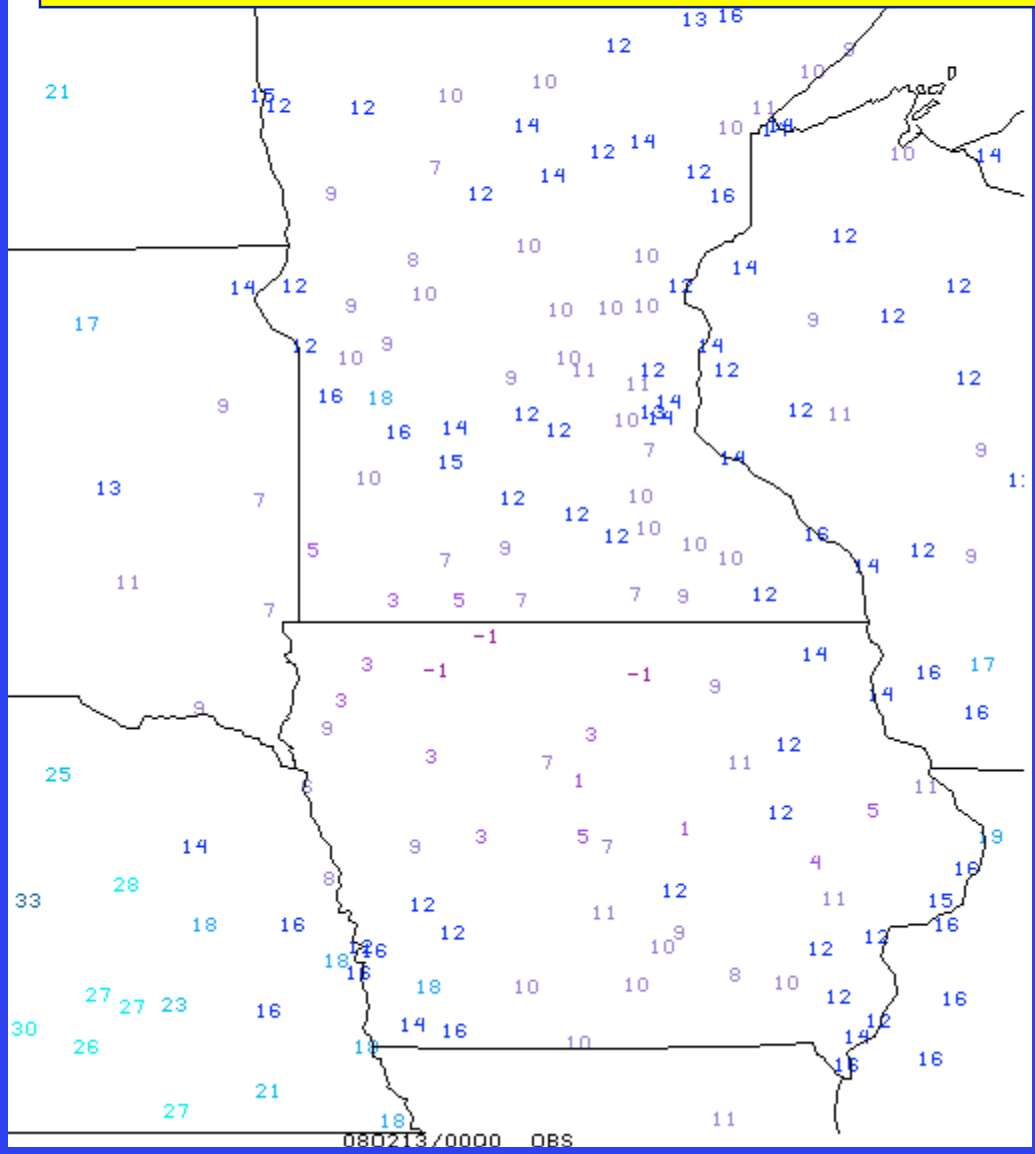


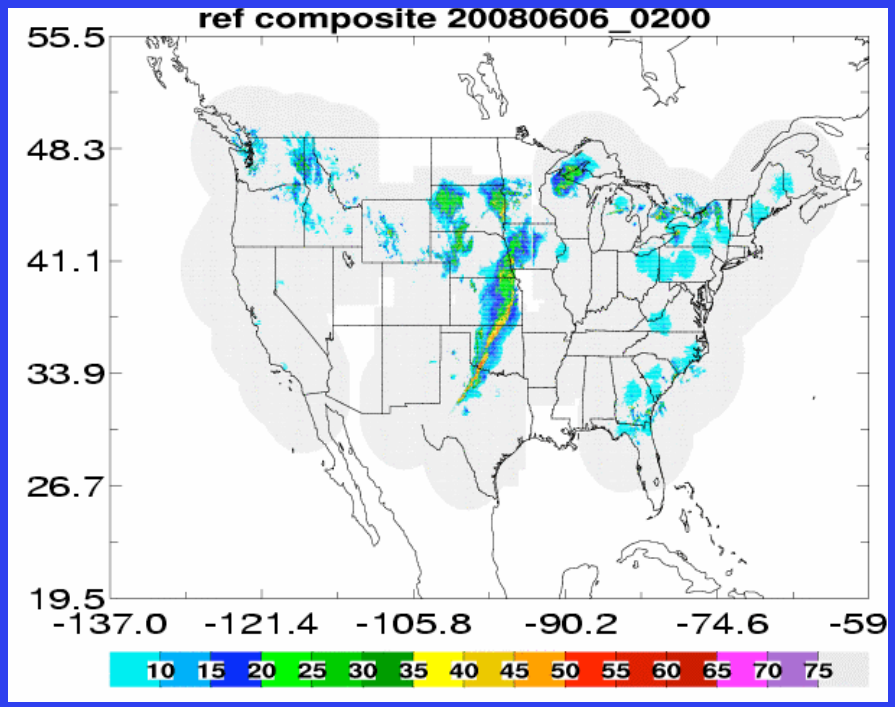


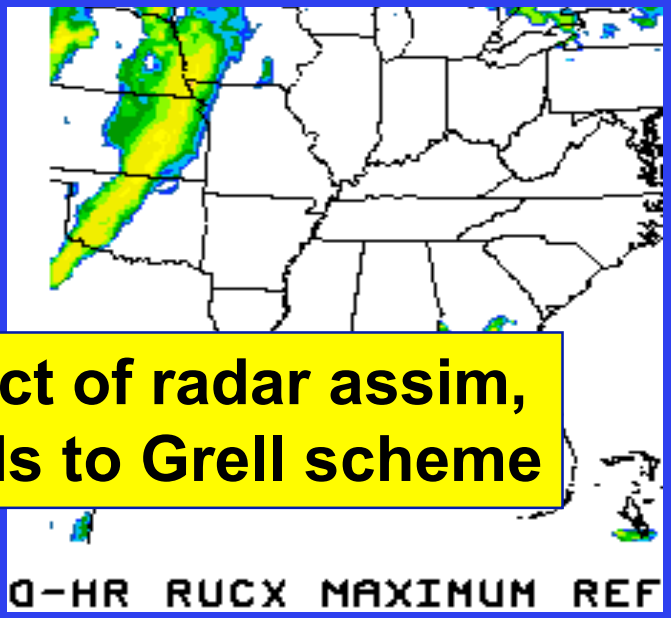




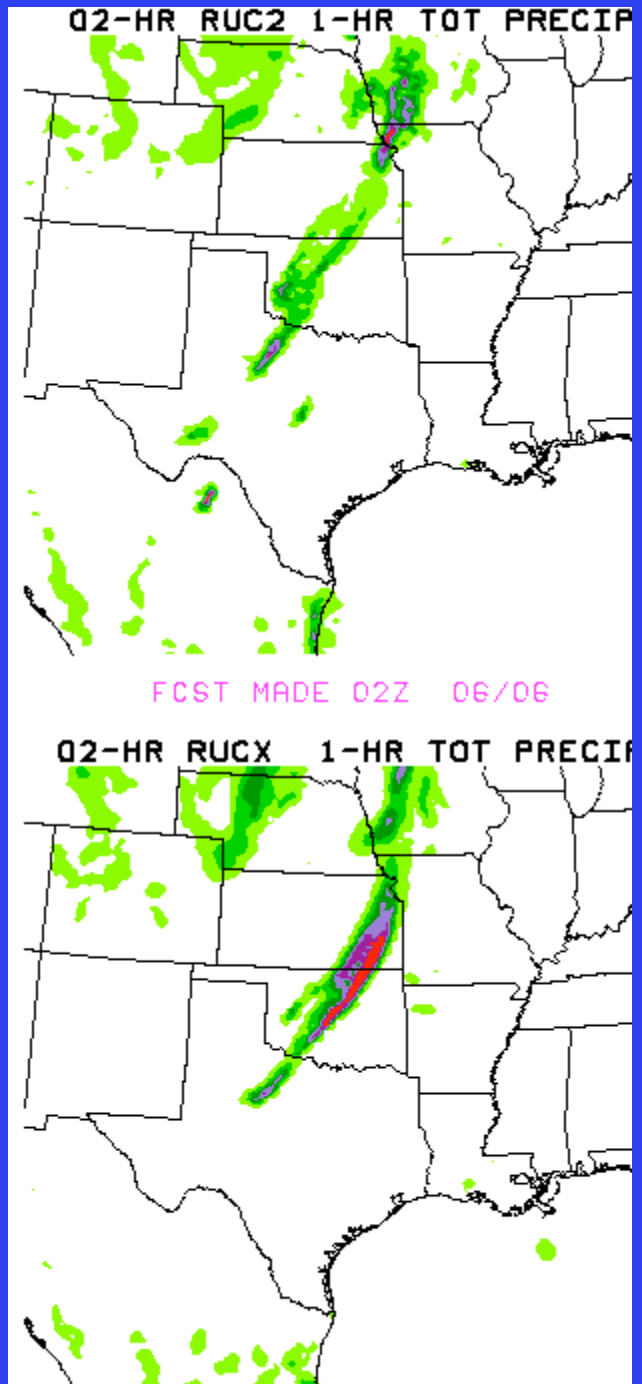
Effect of LSM mod - RUC snow cover, density of fresh snow
- less excessive cold temps

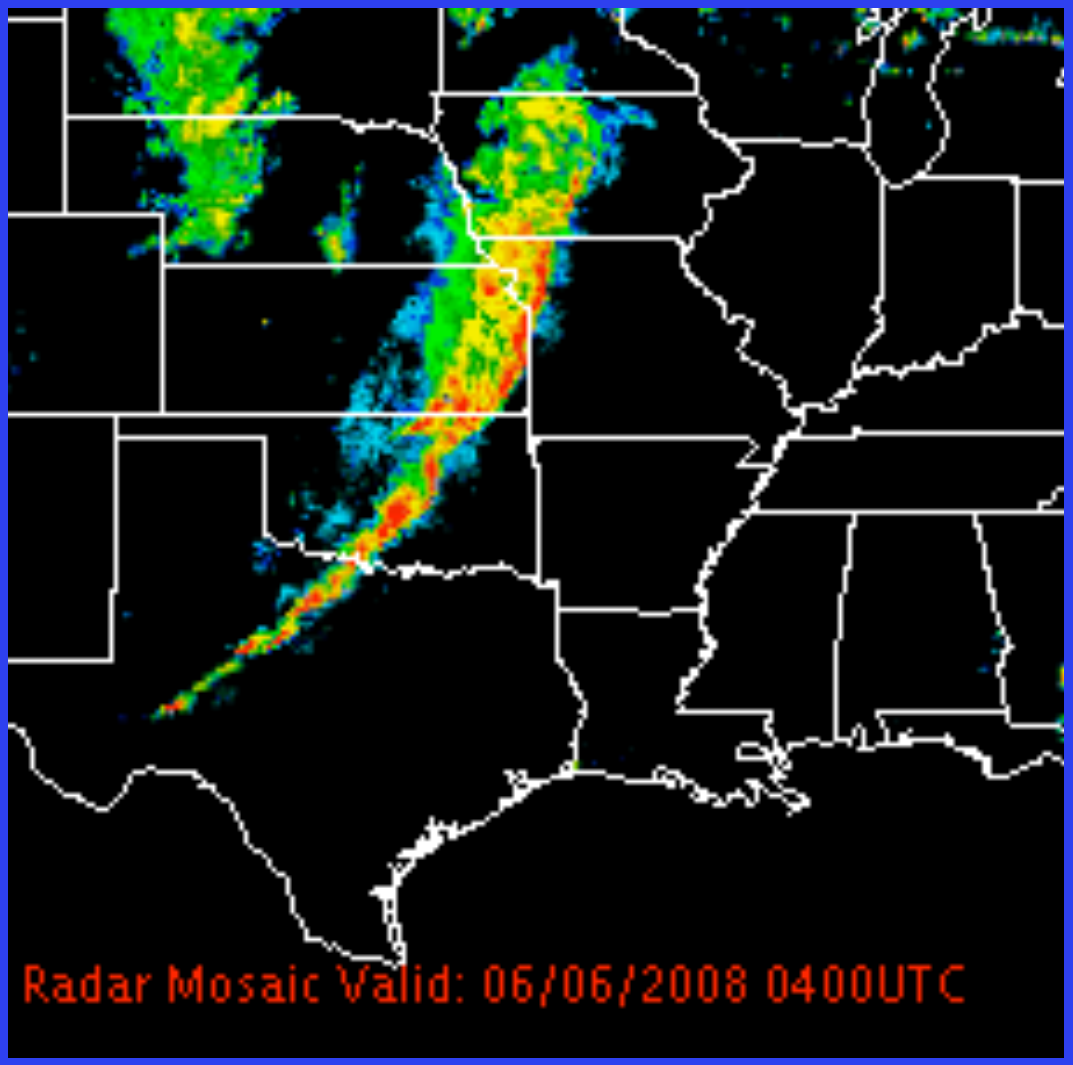


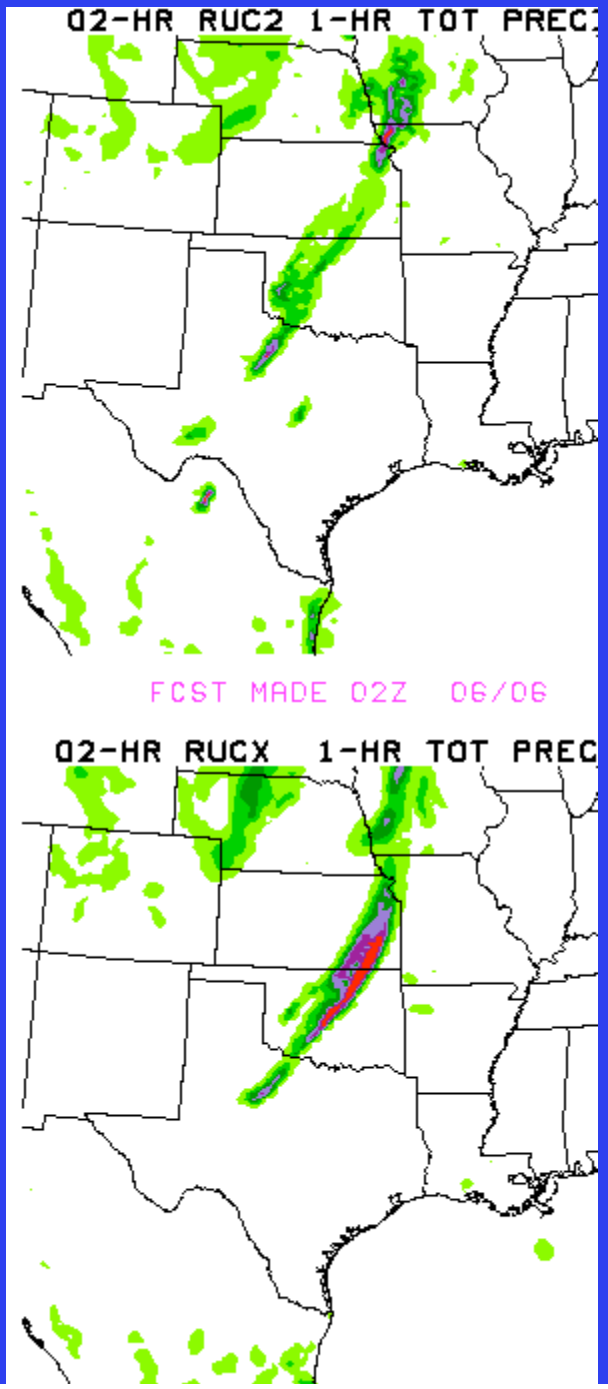


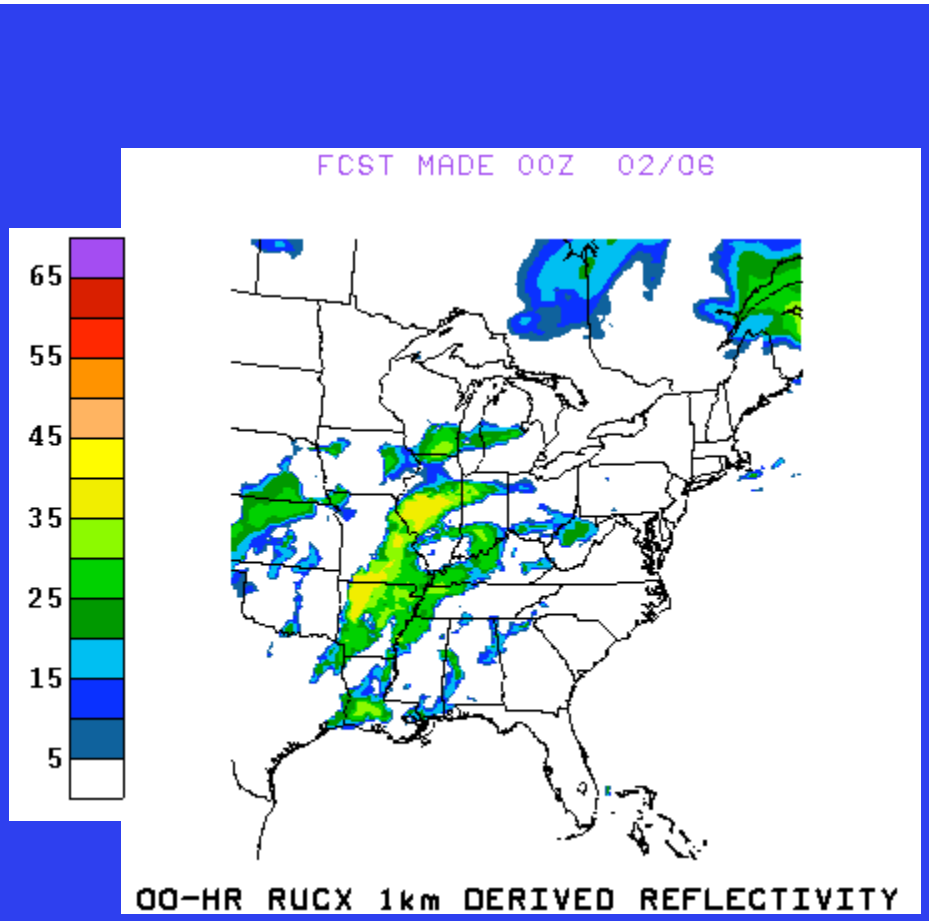


Effect of radar assim, Mods to Grell scheme




Radar Mosaic Valid: 06/06/2008 0400UTC


02-HR RUC2 1-HR TOT PREC
FCST MADE 02Z 06/06
02-HR RUCX 1-HR TOT PREC


FCST MADE 00Z 02/06
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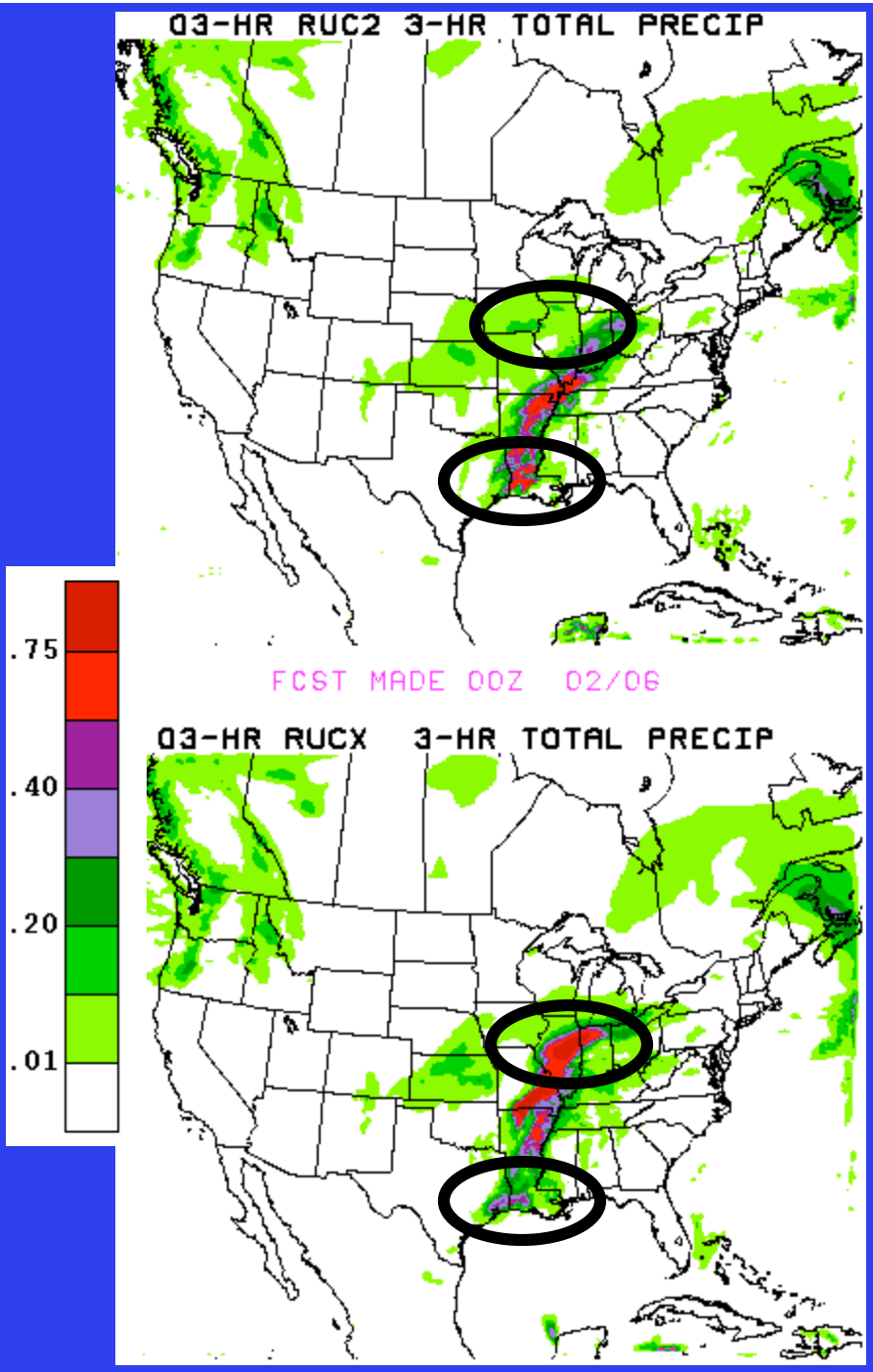
15
5
00-HR RUCX 1km DERIVED REFLECTIVITY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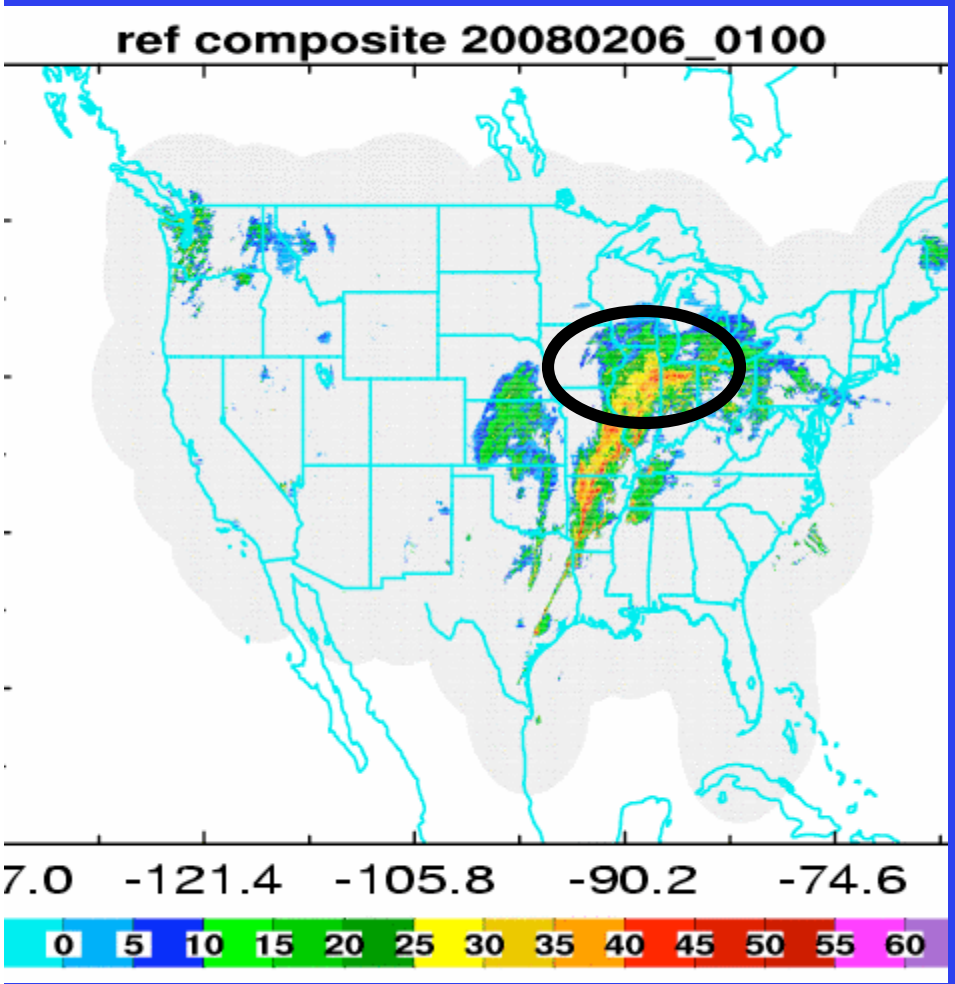
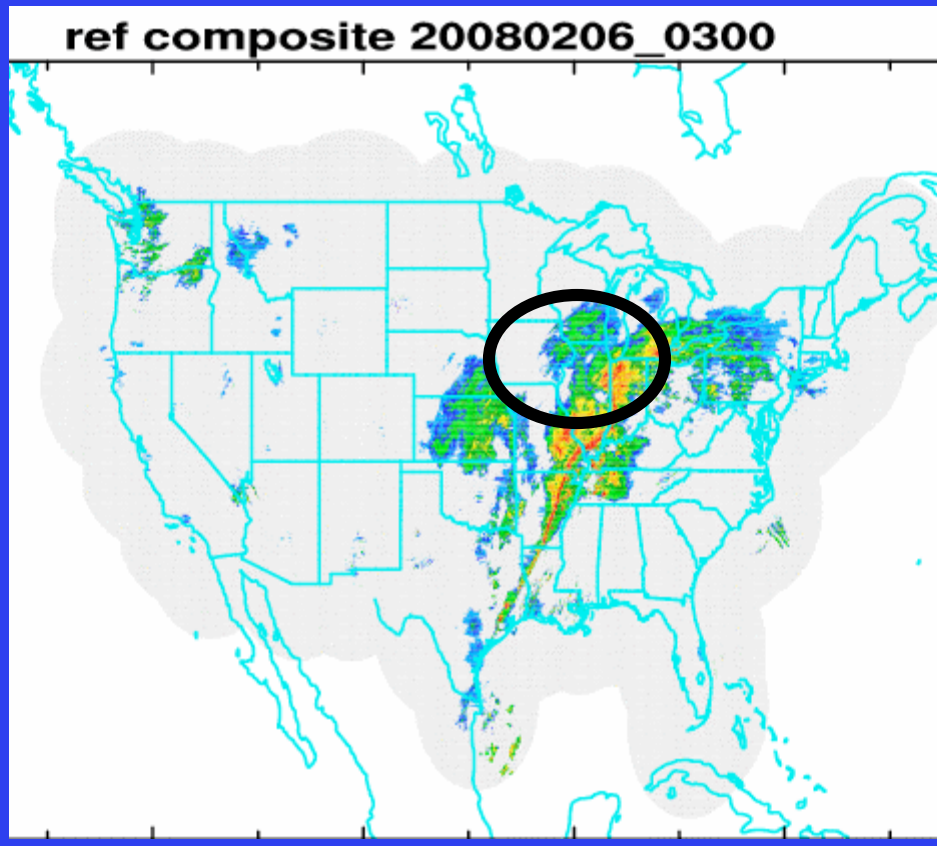
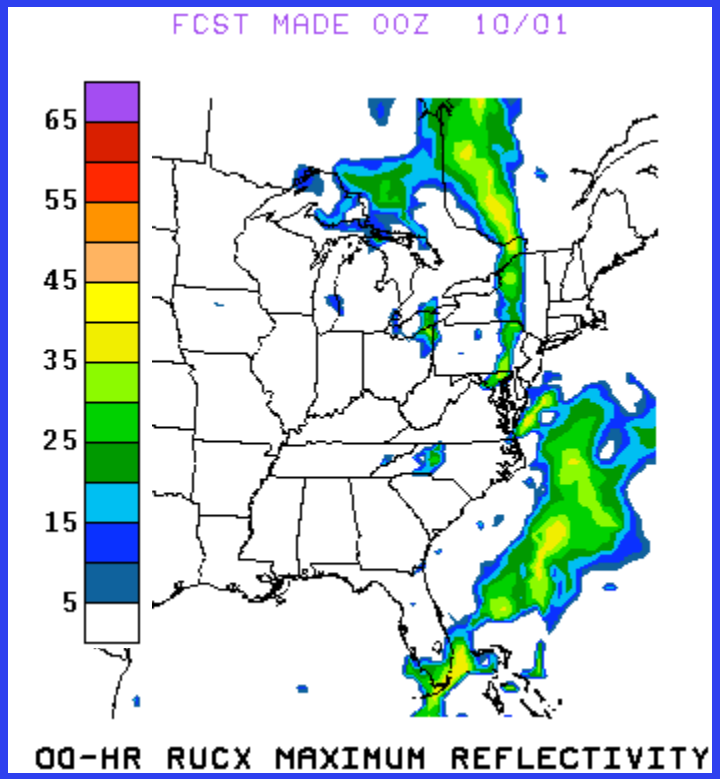
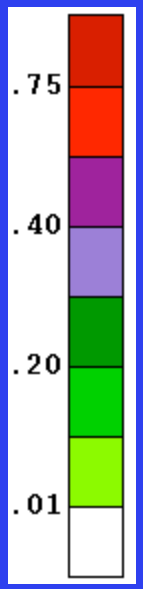
FCST MADE 00Z 02/06
03-HR RUCX 3-HR TOTAL PRECIP

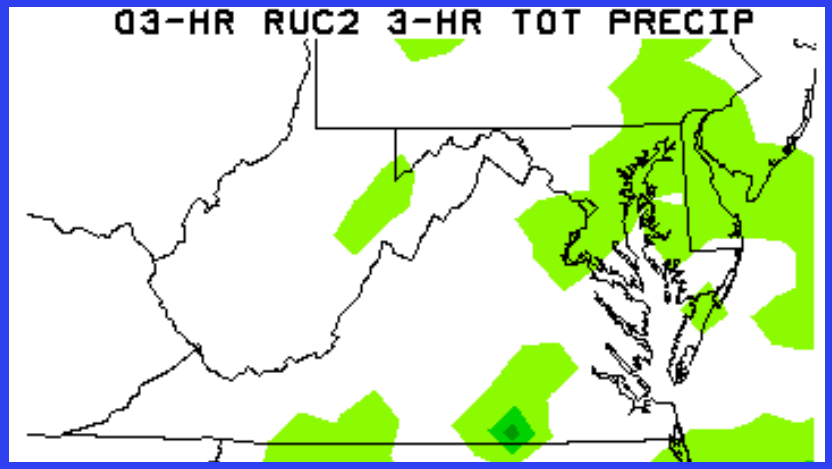


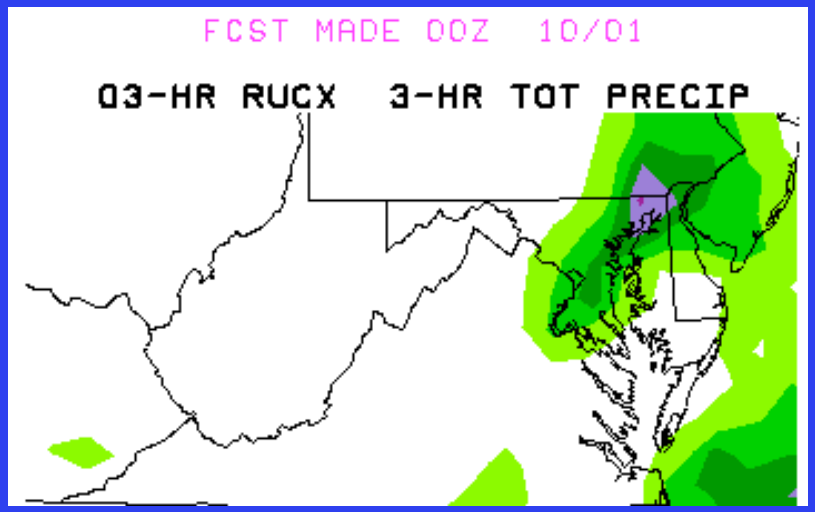


Effect of radar assim, Mods to Grell scheme

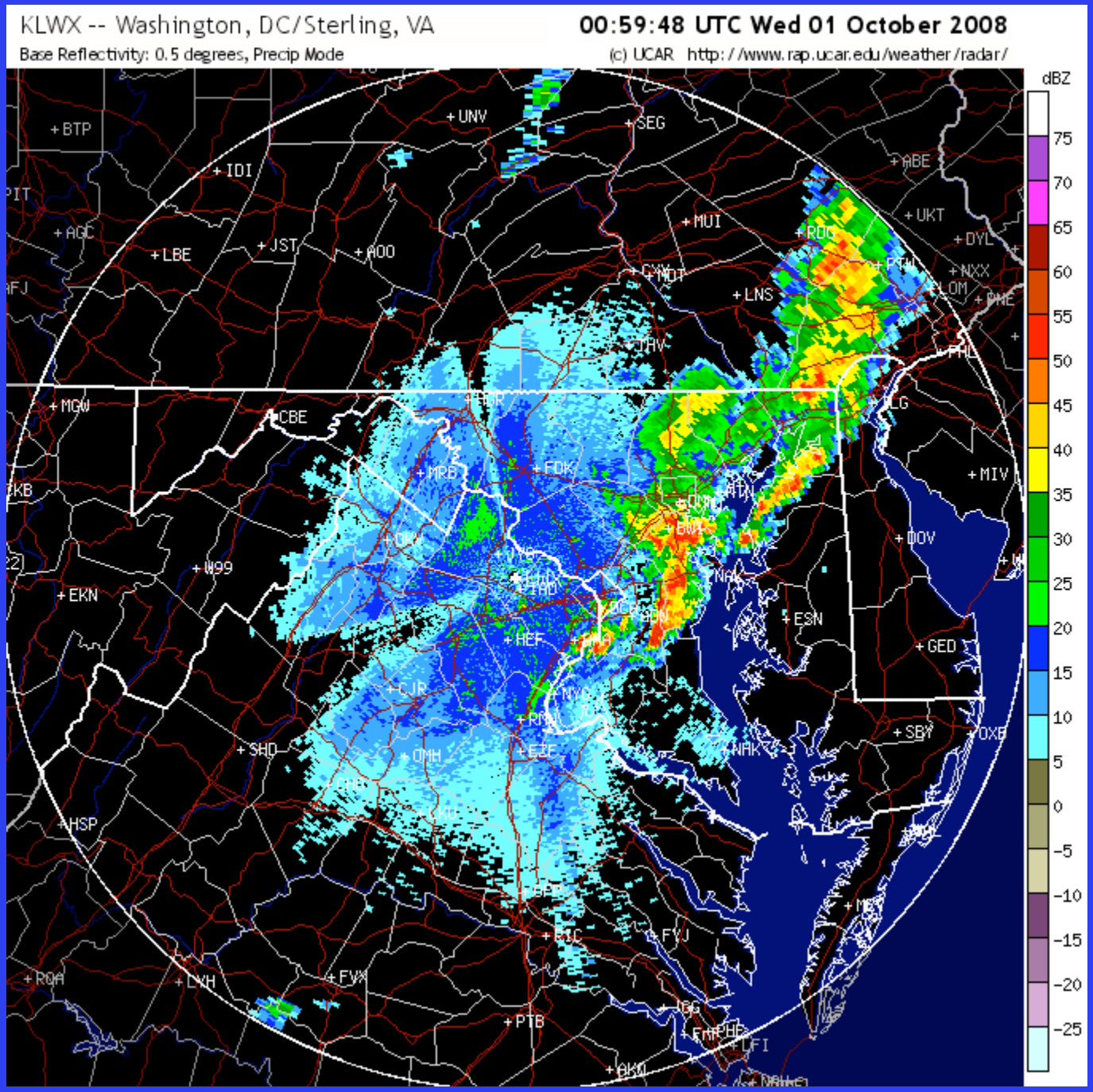








Effect of radar assim, Mods to Grell scheme


KLWX -- Washington, DC/Sterling, VA
00:59:48 UTC Wed 01 October 2008
Base Reflectivity: 0.5 degrees, Precip Mode
(c) UCAR http://www.rap.ucar.edu/weather/radar/
dBZ
75
70
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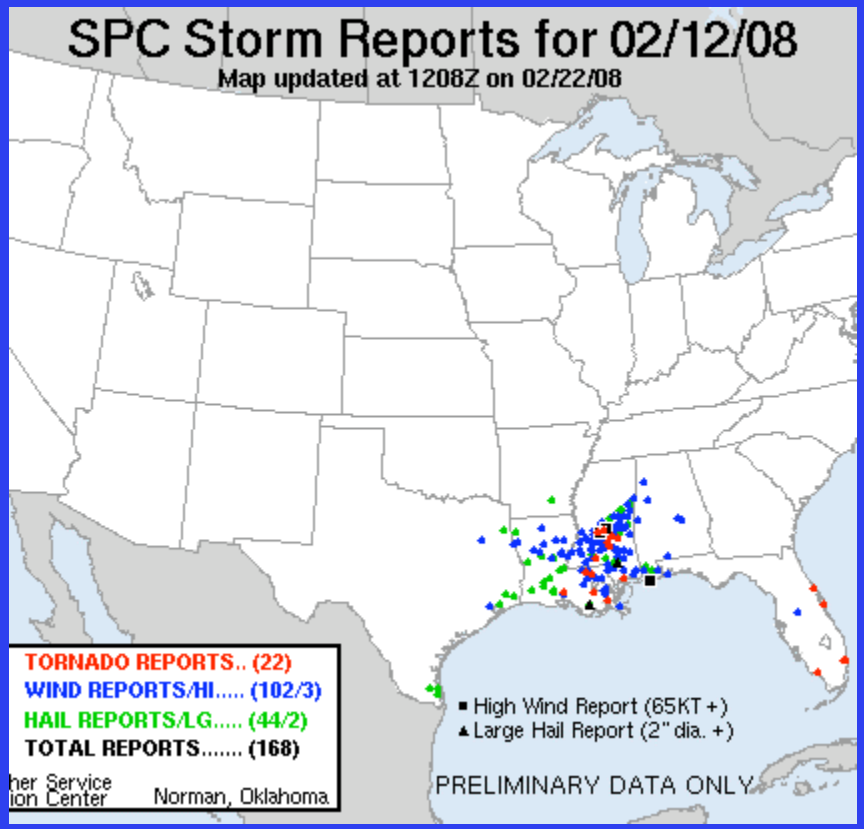
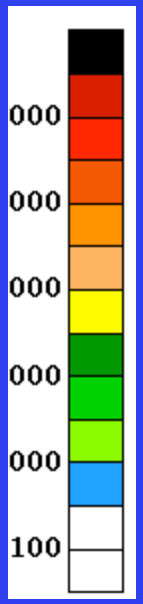

SPC Storm Reports for 02/12/08
Map updated at 1208Z on 02/22/08
TORNADO REPORTS.. (22)
WIND REPORTS/HI..... (102/3)
HAIL REPORTS/LG..... (44/2)
TOTAL REPORTS..... (168)
her Service
ion Center
Norman, Oklahoma
High Wind Report (65KT+)
Large Hail Report (2" dia. +)
PRELIMINARY DATA ONLY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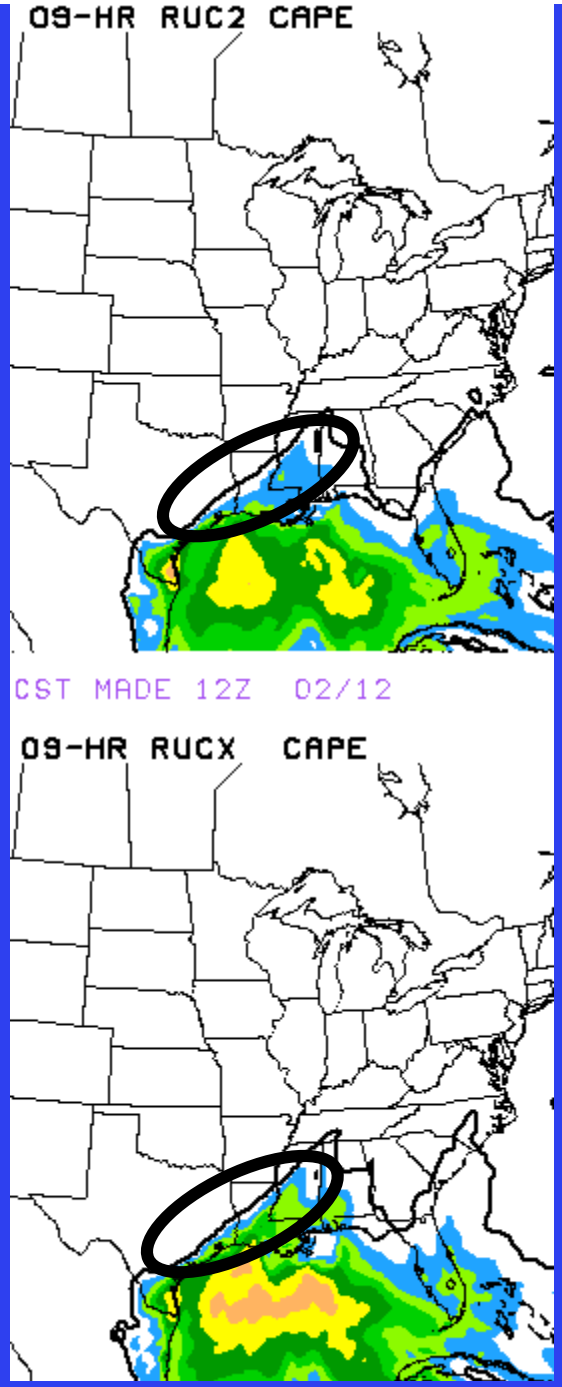
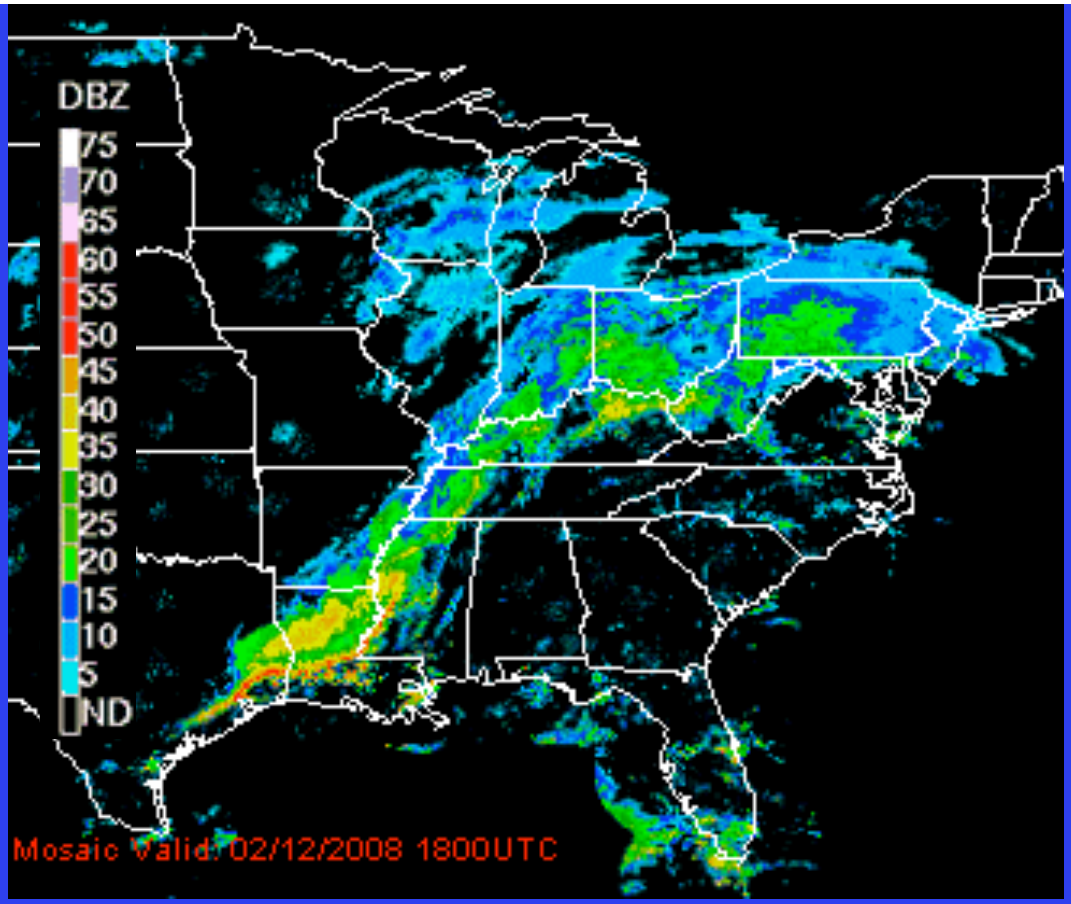

09-HR RUC2 CAPE
CST MADE 12Z 02/12
09-HR RUCX CAPE


DBZ
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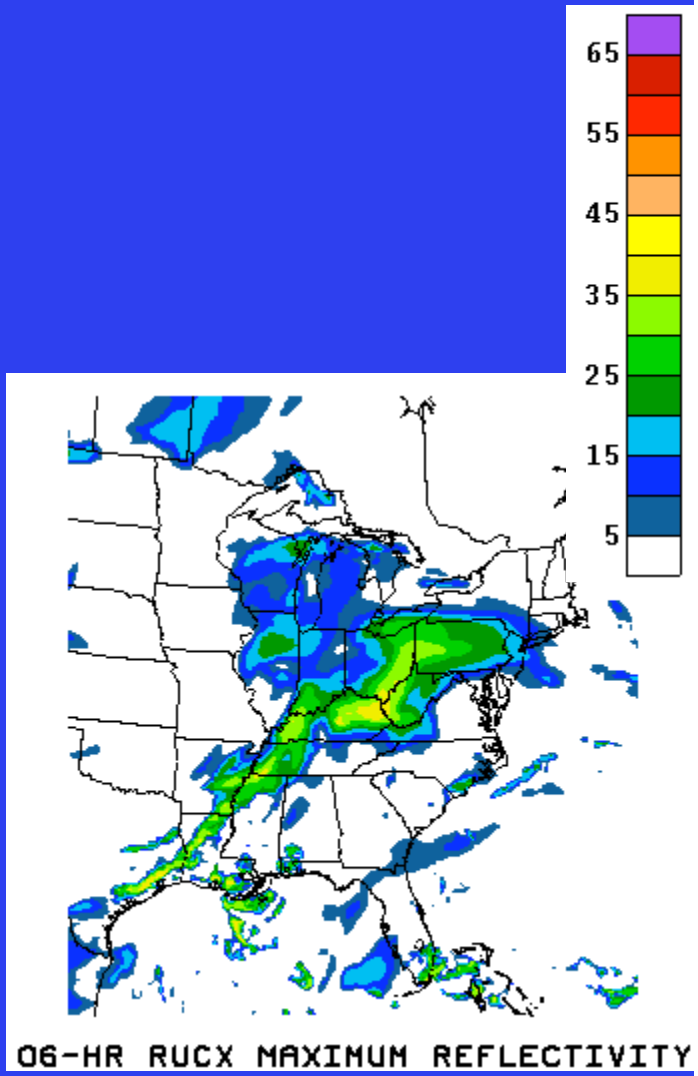
Mosaic Valid 02/12/2008 1800UTC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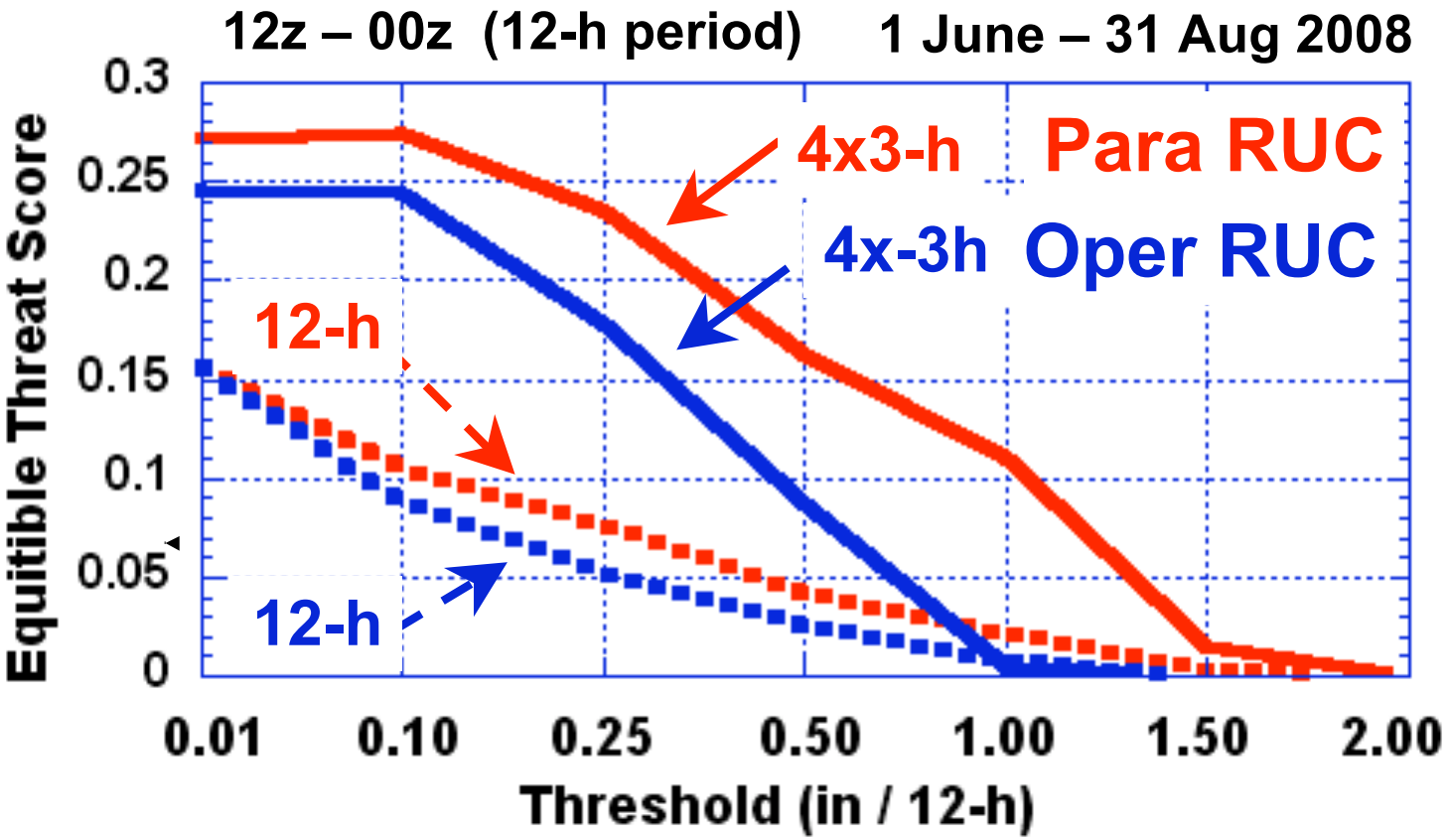
06-HR RUCX MAXIMUM REFLECTIVITY

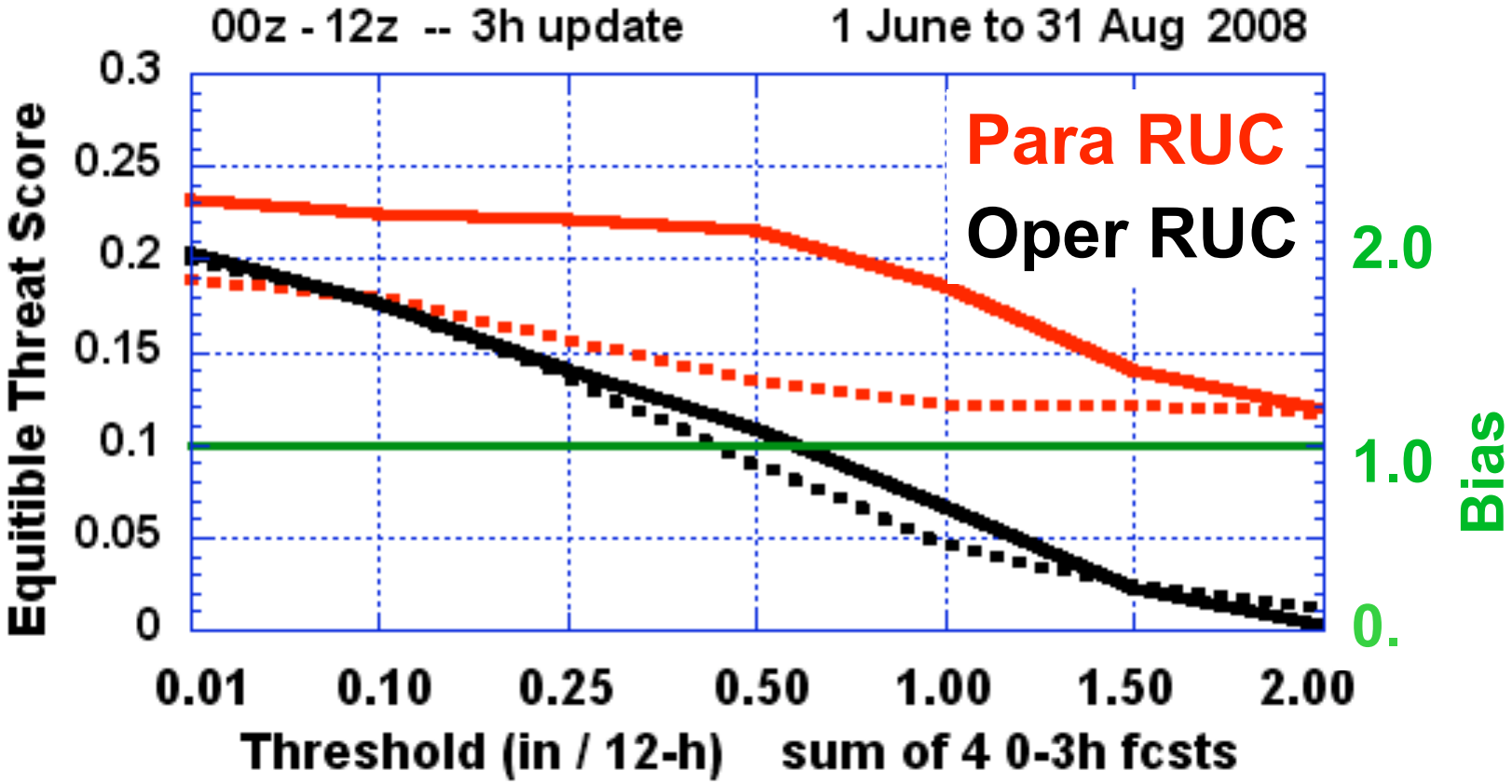
Radar assimilation impact on RUC precipitation skill scores

- Four 0-3h forecasts vs. one 0-12h forecast
- Summer - Daytime

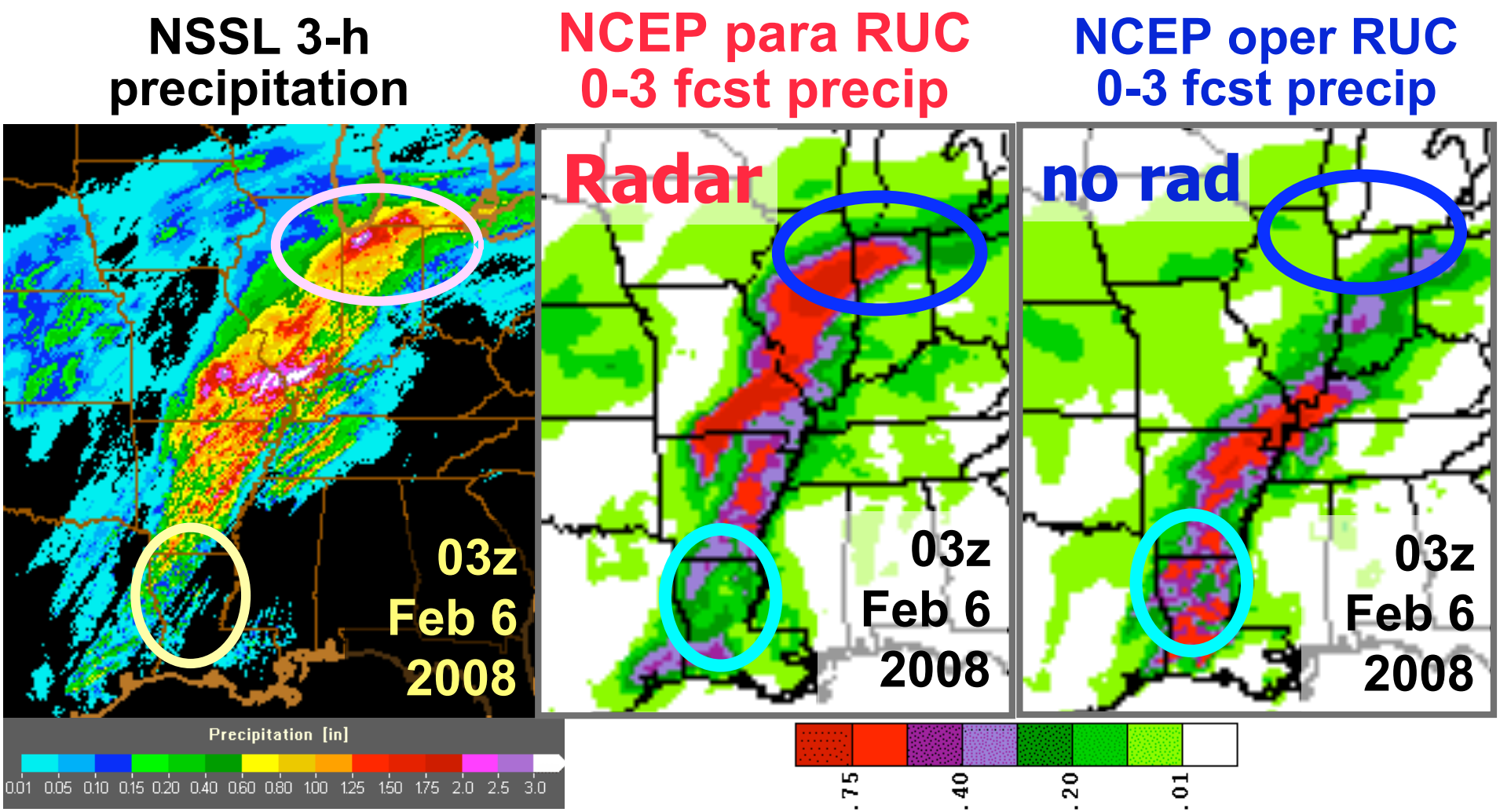


Radar assimilation impact on 3-h precipitation skill scores

- Four 0-3h forecasts
- Summer - Nighttime



NCEP RUC parallel
reflectivity assimilation example



SPC Evaluation of Parallel RUC

October 25, 2008

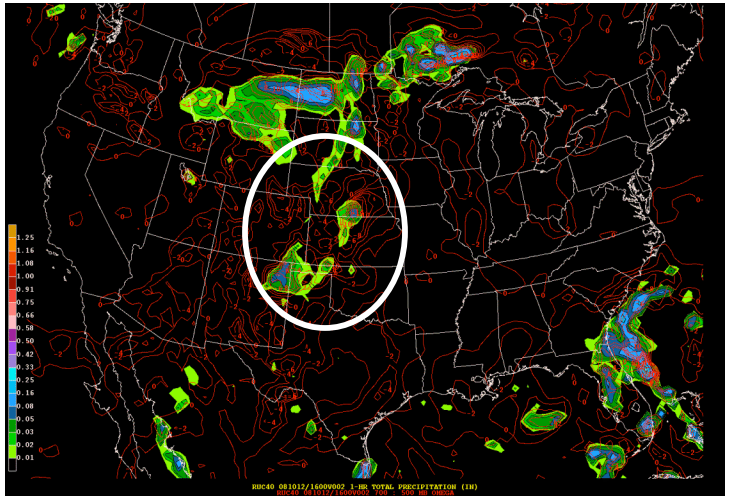
SPC Evaluation of Parallel RUC

- Goal was to examine operational and parallel output on severe thunderstorm days.
  - However, the fall evaluation period coincided with the typical decrease in severe storms.
  - The severe weather sample size was very limited.
- Given the small sample size of real-time severe weather cases:
  - We looked at several spring cases where the operational RUC developed unusual elevated moisture profiles in soundings and compared with parallel soundings
  - Examined warm season verification statistics from RUC parallel web page, especially 2m temperature and dew point forecasts
  - Focused on assimilation of radar reflectivity and its impact on precipitation forecasts.

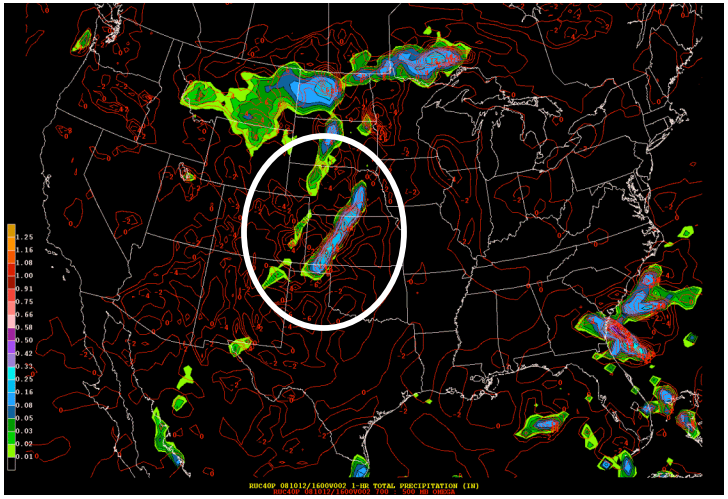
Short-Term 1-hr Accum. Precipitation Forecasts

Valid 16z 11 Oct 2008

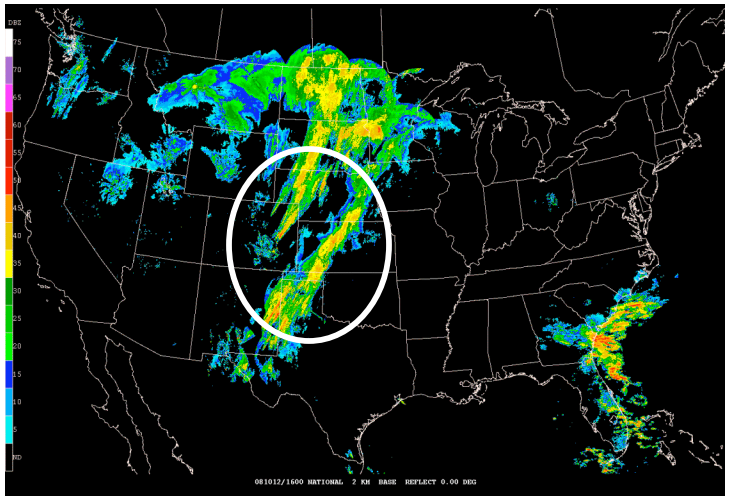
Opnl RUC 2-hr Fcst



Parallel RUC 2-hr Fcst



“Verifying” Base Reflectivity Showing Max Value During 15-16z period.



Use of radar reflectivity in data assimilation often resulted in improved placement of precipitation forecasts for the first several hours. This improvement typically diminished by 03-05 hrs.

SPC Evaluation – Additional Comments

- There were often small-scale differences between the operational and parallel runs in the 2m dewpoint and CAPE/CIN fields
  - These were evident starting at the 00hr time.
  - Differences were seen in point sounding profiles from the two runs.
  - Suggests that in addition to the radar assimilation and associated latent heating profile adjustments, inclusion of other data sources (mesonet, TAMDAR, etc) are impacting the analysis.
  - It was often unclear if the parallel analysis was better or worse than the operational analysis, as there is inherent uncertainty in knowing “what is truth” concerning the smaller-scale state of the 3D atmosphere.
- Bothwell Perfect Prog thunderstorm forecasts
  - This prediction system is sensitive to CAPE.
  - Small changes in CAPE between the parallel and operational RUC impacted these probabilistic forecasts.
  - Again, sample size was small so firm conclusions cannot be drawn at this time.

SPC Evaluation -Summary

- Given the relatively short evaluation period, and the few opportunities we had to compare performance on severe weather days, our input is necessarily limited.
  - There were improvements in sounding structure in spring return flow situations, and short-term precipitation forecasts in the fall.
  - We did not see anything that consistently indicated worse performance in key fields from the parallel run.
- Under these circumstances, the statistical verification results computed over a longer period of time may provide the best overall insights.
  - Improved 2m temp and dewpoint forecasts in warm season.
- **SPC Recommendation – a cautious "thumbs up"** (because of few opportunities to examine performance on severe weather days).

AWC Real-Time Evaluation of the FY08/09 RUC13 Parallel

Dr. Steven Silberberg & AWC Forecast Staff
NOAA/NWS/NCEP/Aviation Weather Center
October 30, 2008

AWC Evaluated

- RUC Analysis, Model, and Post Upgrades and their affect on AWC forecasts of:
  - Wind speed and turbulence diagnostics
  - Icing diagnostics/freezing level height
  - Convection
  - Ceiling and visibility

AWC Evaluation of RUC Parallel Analyses

- RUC Parallel better than Ops RUC for:
  - Surface analyses of 2 m temp, 2 m dewpoint, 2 m RH, BL-RH, & visibility; especially in the western USA and improved surface gust potential over CONUS → critical for IFR, strong surface wind, and low-level wind shear diagnosis and forecasts
  - Analyses of clouds, water vapor, cloud bases/tops, precipitation, and reflectivity → critical for icing and IFR diagnosis and forecasts
  - Resolution of upper air features → improved turbulence diagnostics/jet structure
  - Highest freezing level height → improved icing forecasts

AWC Evaluation of RUC Parallel Forecasts

- RUC Parallel better than Ops RUC for:
  - Jet streams and turbulence diagnostics
    - Better Ellrod and Ri diagnostics
  - Cloud and Icing diagnostics/freezing level height: higher % of icing in regions where pilot reports indicate icing
  - Convection: location and initiation
  - Ceiling and visibility → better IFR forecasts
    - Still have problems forecasting radiation fog

AWC Comments on RUC Parallel Post-Processing

- AWC greatly appreciates the addition of:
  - Reflectivity fields similar to the NAM → improved convective initiation and location guidance
  - Modified ceiling diagnostic to avoid excessive LIFR (Low Instrument Flight Rules) conditions
  - Accumulated total precipitation and snow fields

Conclusion

- RUC Parallel a significant improvement over OPS-RUC for aviation
- AWC STRONGLY RECOMMENDS ADOPTION OF THE RUC13 PARALLEL → 2 THUMBS UP!
- AWC acknowledges ESRL/GSD, EMC, & NCO, for: a) RUC improvements, b) implementing AWC feedback, and c) arranging dataflow for the real-time evaluation
- AWC would like the on-time RUC extended to F24 and provide hourly output to F18, + F21, & F24 for Graphical Forecast for Aviation (GFA) → we'll always ask for more improvements…Thanks

Nov 2008 Changes for oper RUC upgrade - forecast performance improvements

- Surface temperature and winds
  - Much lower bias, all times of day and seasons
- Precipitation, reflectivity
  - Much improved QPF all seasons, new reflectivity product consistent with reflectivity observations
- Ceiling and visibility
- Lower tropospheric temperature, RH in eastern US
- Improved RTMA downscaling and accuracy

RUC parallel web site:
http://www.emc.ncep.noaa.gov/mmb/ruc2/para